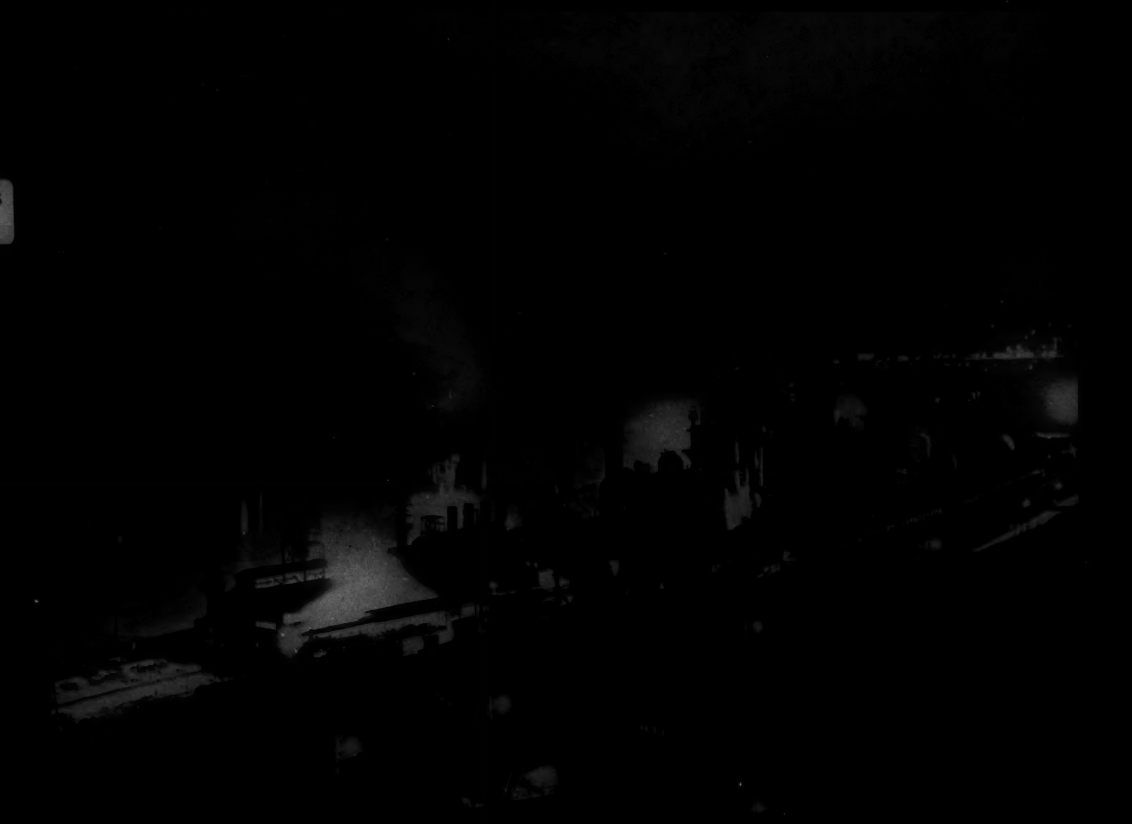
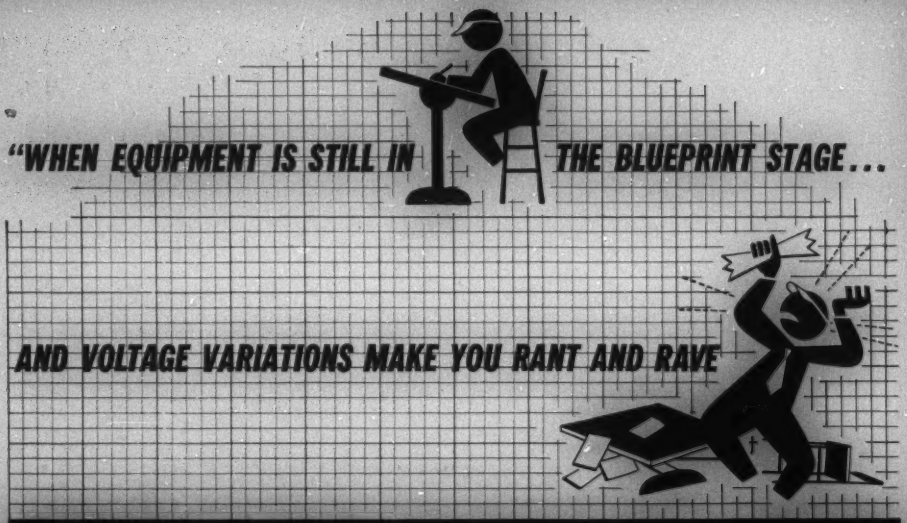
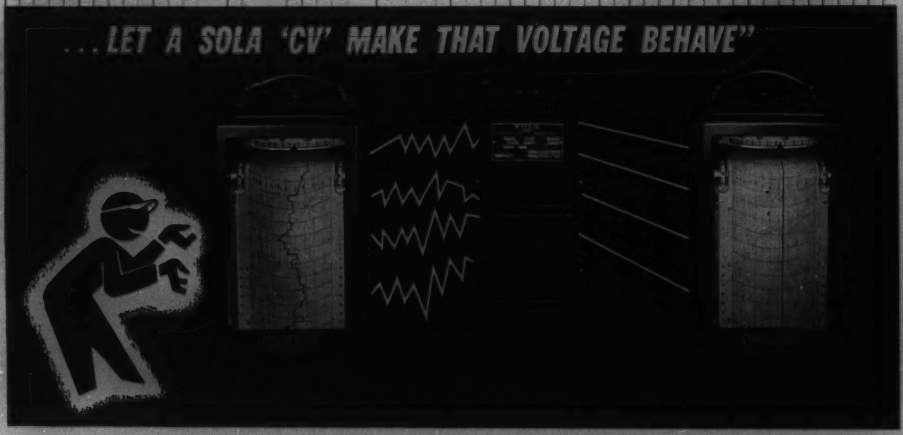
ELECTRICAL ENGINEERING

DECEMBER 1947



AIEE WINTER GENERAL MEETING, PITTSBURGH, PA., JANUARY 26-30, 1948





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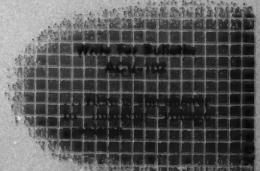

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ELECTRICAL ENGINEERING

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DECEMBER
1947

The Cover: Night view of the Edgar Thompson works of the Carnegie Steel Company in Pittsburgh, Pa., the city which has been selected for the 1948 winter general meeting site, January 26–30.

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Where there is Horsepower–

There is Wire

Man has always wanted news—and felt a frantic urge to "get the message through." There were shouters on the hilltops—a runner to announce the Persian loss of Marathon. Then horses sped the mails; but they were yet too slow—too slow for instance to prevent a battle after the peace was signed.

The telephone was a novelty in 1902—when Belden Manufacturing Company was founded. The story of instantaneous communications reads on from there.

Words have conquered space and time—because the products of the wiremakers have harnessed horsepower.

HIGHLIGHTS.....

Meetings. The week of November 3rd in Chicago was one packed with electrical group activity. The AIEE Midwest general meeting was held at the Congress Hotel (*pages 1232–33*); the 3-day National Electronics Conference was going on at the Edgewater Beach Hotel (*pages 1220–29*); and the Second International Lighting Exposition was shown at the Hotel Stevens (*pages 1240–41*).

500-Kv Tidd Line. Past experience and careful analysis indicates that substantial economies may be realized in power transmission by operating at extra high voltages. However, much performance data are needed before extra-high voltage power transmission can be made practical. The Tidd high-voltage test project is expected to produce this needed data (*pages 1178–81*).

Nucleonics Primer for Engineers. A series of articles prepared by the AIEE nucleonics committee for *ELECTRICAL ENGINEERING* will constitute an authoritative textbook and reference providing an up-to-date perspective of the several phases of atomic research and nuclear theory. The general history of atomic research and basic concepts are discussed (*pages 1165–75*). Other articles will continue with such subjects as the relation between mass and energy, nuclear engineering, production of high energy particles, isotope separation, nuclear piles, radiation health hazards, and engineering applications.

Japanese Utilities. From his experiences during a 4½-month survey of the Japanese electric power system, E. J. Burger has written an article describing the differences between Japanese and United States equipment and the effect of operating practices, methods of allocating power, personnel practices, and the war on Japanese electric power output (*pages 1201–06*).

Electric Flow Meter. Considerable advantage can be expected from a flow metering method which eliminates a nonlinear relationship between flow rate and measured value, the need for converting a mechanical signal into an electric one, and direct contact between the measuring elements and the fluid which may result in contamination, corrosion, or leakage (*pages 1216–19*).

Overcast Need Not Prevent Aircraft Landings. The Army Air Forces, in conjunction with other organizations, is conducting tests to improve methods of landing through overcast. With co-ordinated electronic and lighting aids, daytime landings are practicable with visibility as low as 660 feet. With the addition of thermal aids, even lower visibility can be tolerated. If aviation adapts itself, much of the irregularity of air transportation can be eliminated (*pages 1176–77*).

Electric Drive for Aircraft. The use of a large amount of power in aircraft becomes a power-handling problem, and the electric transmission from the turbines mounted in the fuselage to the propellers on the wings has the same advantages as in handling very large amounts of power in industry. Centralized electric drive offers the advantages of flexibility, reliability, ability to shut down prime movers, and lessened drag. Increased weight is its principal disadvantage (*pages 1206–08*).

The Sun Sings. One of the many strange phenomena contributable to solar radiation is radio-frequency waves which, when demodulated, sound much like bird calls. This brief history of solar radiation studies points out that modern predictions of weather, radio transmission, corona discharge, and so forth, result from 4,000 years of solar investigations (*pages 1209–13*).

Colorado River Projects. If full advantage is to be taken of the resources of the Colorado River, careful study must be made of the engineering and economic features of each of the 134 proposed projects. The improvement of the entire basin must be planned with the view of best serving all the interests involved (*pages 1184–93*).

An Overcurrent Tripping Device. A new overcurrent tripping device for low-voltage circuit breakers has been developed in which the timing characteristics are obtained by the positive displacement of fluid in a hermetically sealed chamber. The universal characteristics of the new device permit the replacement of both the old thermal-magnetic and dual-magnetic units with one universal trip unit which is equally applicable to a-c or d-c service (*pages 1194–97*).

Power System Governing. A governing system is proposed which "is based upon the concept that optimum division of load among generating stations is inherent if integrated frequency variations from standard time are controlled within limits of the same order as transmission-line torque angles" (*pages 1197–1200*).

Engineering English. The engineering student's natural apathy to nontechnical subjects and the typical instructor's lack of technical training makes teaching English in engineering schools a difficult problem. Two English professors suggest a solution in the form of a new type of English teacher—one trained both in engineering and English (*pages 1182–84*).

Correction. In a personal item on D. J. O'Conor, Jr. (*EE, July '47, p 710*) Mr. O'Conor was reported incorrectly as having been cofounder, with his father, of the Formica Insulation Company, Cincinnati, Ohio, the firm with which he is associated. Actually, the Formica Company was founded by D. J. O'Conor, Sr., with Herbert A. Faber, who now is inactive in the business.

Two corrections and an addition are in order in Table I of the summer general meeting Institute news item, "Five-Year Curriculum Engrosses Education Session," which appeared in the August issue of *ELECTRICAL ENGINEERING* (*p 817*). In column 1 of the table under the heading "4. Departmental:" "electric machine theory" should be eight quarter hours and "electrical engineering economy" should be four quarter hours. "Electric machine laboratory, four hours" should be added.

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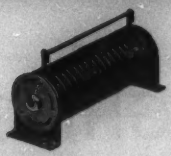

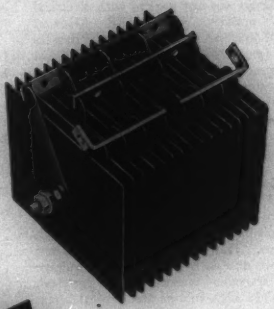

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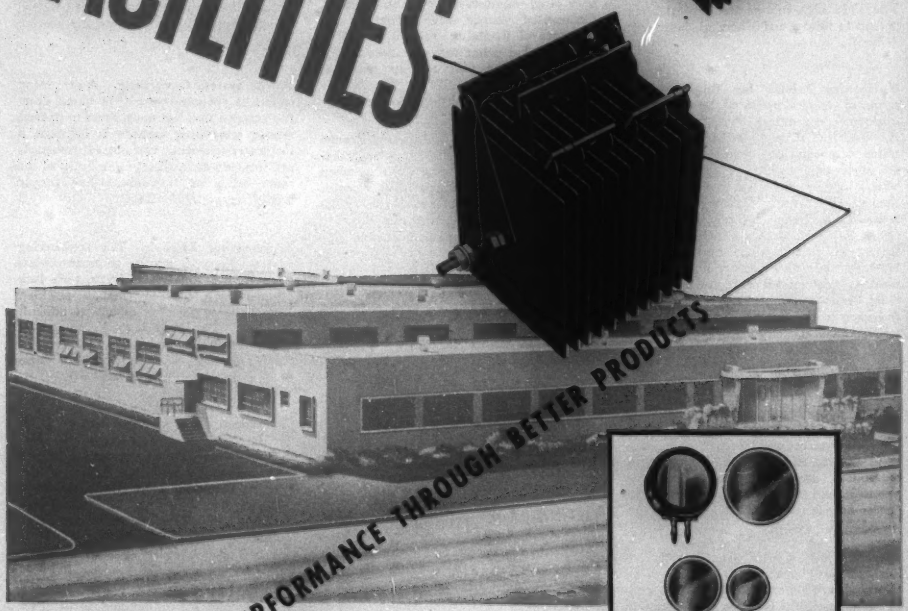

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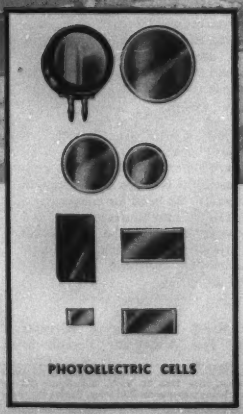

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47-1

The Atom and Its Nucleus

J. J. SMITH
ASSOCIATE AIEE

The first of a series of articles prepared by the newly formed AIEE nucleonics committee, this discussion gives a general introduction to the rapidly developing field of atomic research. The series will be a primer in nuclear theory for engineers, and will include such timely subjects as nuclear engineering, production of high energy particles, isotope separation, nuclear piles, and health hazards.

MAN'S SEARCH for a clearer understanding of the nature and composition of the material things surrounding him is as old as recorded history. The ancient philosophers sought a simple explanation of the structure of matter. The first of the Greek philosophers believed that all matter originated from a single substance. Some thought the primordial substance was water, others held it was air, or earth, or fire.

Empedocles (490–430 B. C.) combined the ideas of his predecessors in the belief that there were four fundamental substances, earth, air, fire, and water, and that all matter was composed of combinations of these substances.

Democritus (460–370 B. C.) believed that all matter was made of atoms (meaning "indivisible") having form, size, and weight, but being so small as to be invisible and without color, taste, or smell. He further believed these atoms to be in ceaseless motion and that atoms of the same substance were homogeneous but atoms of different substances had different characteristics.

The ancients certainly were acquainted with copper, gold, silver, iron, lead, mercury, carbon, sulphur, and perhaps a few others, but the recognition that these were elements as we know them today, was slow in coming. In general, the early philosophers were satisfied to build up their theories by the process of logic without resort to experimentation to test them.

A clearer conception of the importance of the atom first began to emerge early in the 19th century. In 1805 Gay-Lussac and von Humboldt demonstrated that one volume of oxygen and two volumes of hydrogen always would react to form water. If either was present in excess of that proportion, it remained uncombined. At virtually the same time Dalton showed that hydrogen and oxygen always combined in the proportion of one to eight by weight to form water. From there it was an easy step to the conclusion that water was formed by the combination of two atoms of hydrogen with one of oxygen, and that the weight of the oxygen atom was 16 times that of the hydrogen atom. Following the same line of experimentation and reasoning, atomic weights were determined for all of the then known basic substances or elements. The discovery of the 92 elements which occur in nature took place over a long period of time.[1]

Another major step in the development of atomic theory was Mendelejeef's discovery of the periodic law in 1869, the fundamental idea being that the properties of the elements are a periodic function of their atomic weights. His table in modern form is shown in Table I. As an example of the use of the table, we recognize in column 2 the elements lithium, sodium, potassium, rubidium, and caesium. These are the so-called alkali metals and have in general very similar properties. In column 2 also will be found copper, silver, and gold, a group with quite dissimilar properties. The explanation of the presence of this second group was not found until many years later. By use of this table, it was possible to predict the properties of certain elements even before they were discovered. This was a great help to the experimental chemists because by knowing the properties of an element in advance they could guide their search for it by its predicted properties.

There were, however, a few points in Mendelejeef's table which were something of a puzzle and pointed the way to further research. For instance, the atomic weight of cobalt is 58.94 and that of nickel is 58.69, but still from their properties it was necessary to put cobalt before nickel in the table, although its atomic weight is greater than that of nickel. Another puzzling feature of the table was the fact that the atomic weights were not whole numbers as would be predicted by the postulation of similar building blocks for all the elements. For instance, the atomic weight of mercury is 200.61 and careful measurements showed that the fractional part of 0.61 could not be the result of experimental error.

This problem engaged the attention of many physicists and the answer was found about 1910 by J. J. Thomson and F. W. Aston working with the mass spectrometer. This is a device in which, as its name implies, the masses of elementary particles can be measured. The substance to be measured is prepared in the form of a gas, and the molecules, after being ionized, are accelerated by an electric field and then

J. J. Smith is assistant engineer in the general and consulting engineering laboratory of the General Electric Company, Schenectady, N. Y.

deflected by a magnetic field. From the deflection, the ratio of the charge on the particle to its mass can be calculated, and knowing the charge on the particle from other experiments, its mass can be calculated. In working with the gas neon, atomic weight 20.183, in as pure a form as possible, Thomson detected the presence not only of a component of atomic mass 20, but also found present a component of mass 22 in much smaller quantity.

This component of mass 22 corresponded to no known element at that time and, after considerable study, it was decided that neon existed in at least two forms—one with an atomic weight of 20 and the other with an atomic weight of 22. Since that time a form of neon of an atomic mass of 21 has been found. It thus appeared from mass spectrometry work that a given element might appear in forms which were chemically identical but with masses which differed by approximately one unit or a multiple of one unit. The fact that they were chemically identical meant that it was impossible to make a separation of these by chemical means. The name isotope was assigned to these different forms of the same element which were chemically indistinguishable.

Subsequent to Thomson's work, Aston, Bainbridge, and many others made extensive studies of the masses of the various elements. This showed that the approximately 92 elements found in nature could be broken down into a total of about 280 isotopes, or an average of 3 isotopes per element. Of course, some elements have fewer, for instance, gold has only one and others have more. The largest number of stable isotopes occurs in tin, which has 10. Stable isotopes are the ones found in nature. If radioactive isotopes, which can be made by piles, cyclotrons, betatrons, and other types of accelerators, are included, the number of known isotopes becomes very much larger, the number at present being more than 800 and still increasing. This explains the large fractional differences in atomic weights from whole numbers by the discovery of isotopes, but the explanation has not been given as to why some of the elements do not fit exactly in their proper places in the atomic table as in the previously mentioned instance of cobalt and nickel. To discuss the subject of atomic numbers as contrasted with atomic weights it is necessary to review some parallel lines of work which had been going on concurrently with the studies of the atoms of elements.

ELECTRONS, PROTONS, AND ALPHA PARTICLES

The law of electrolysis discovered by Faraday about 1834 pointed distinctly to an atomic property of electricity. It showed that a given quantity of one element always carried the same charge or an integral multiple of it in any chemical reaction regardless of what elements might be present. The fact that one gram of silver always carried the same amount of electricity, no matter what the chemical reaction was, seemed to indicate clearly that each atom was associated with a definite electronic charge or a multiple thereof, and that this was not further divisible.

A second line of work going on had to do with the spectra of the various atoms. When, for instance, the light from an incandescent gas is analyzed by means of a spectrograph, a number of bright lines appear which are characteristic of the gas. These spectra have definite regularities, and formulas were derived which could be applied to a large number of different atoms to give the correct frequencies by calculation. An example of such a formula is

$$\nu = RZ^2\left(\frac{1}{n_f^2} - \frac{1}{n_t^2}\right) \qquad (1)$$

where

ν = the frequency of the light corresponding to a given line in the spectrum of the given element
Z = the number of charges in the nucleus of the atom
n_f and n_t = integers where n_f is taken to be smaller than n_t
R = the Rydberg number which turns out to be a constant for all atoms

In addition to this simple formula for the line spectra of the elements, Zeeman discovered that when the emitting source was placed in a magnetic field, a change of frequency of these lines occurred and a single line was divided into two or more lines. This again suggested a relationship between the atom and an electronic charge. The magnitude of this change enabled an estimate to be made of the ratio of the charge on a hypothetical electron to its mass. This estimate coincided very closely with that previously obtained from the aforementioned experiments in electrolysis.

A third line of approach was found by J. J. Thomson and others. In cathode-ray tubes electrons are produced by a hot filament or other means and then accelerated through an electric field giving a stream of electrons of practically uniform velocity. It was found possible to deflect the beam by known electric and magnetic fields and calculate the ratio of the charge to the mass. The results obtained from these experiments gave a ratio of charge to mass identical for all practical purposes with that previously referred to by the method of electrolysis and spectroscopic data. With such definite indications that there existed an indivisible particle of electricity, it was not long before an experiment was devised actually to demonstrate its existence. Thomson and Wilson and others experimented from 1897 on with methods of allowing droplets of water to fall under the effects of gravitation and then applying an electric field. When no field was present, the droplet would fall under gravity; but if an electric field was applied to counteract the earth's electric field, the droplet could be made to stop its downward motion and rise. This showed there must be a charge on the droplet and the amount of charge could be calculated. In

1909 Millikan used oil to minimize the evaporation from the droplet and continued with a very careful series of experiments which showed that the charge on the particle is always 4.774×10^{-10} electrostatic units or a multiple thereof. This experiment has been performed many times since then, and the value of the charge has been confirmed, the accepted value now being 4.8×10^{-10} electrostatic units.

This atomic particle of electricity is called the electron. With its discovery other parts of the atomic picture begin to fit together to form a clearer view of the composition of the atom. In the first place, it was known that the mass of the hydrogen atom was about 1,800 times the mass of the electron. This can be obtained readily by deflecting beams of hydrogen ions and electrons in magnetic and electric fields. It also could be verified from electrolysis experiments.

Secondly, the periodic table showed that whatever the constitution of the atom, it definitely was associated with steps of 2, 8, 8, 18, 18, and so forth. This can be seen by looking at Table I where the first series of 2 ends with hydrogen, the second series of 8 ends with fluorine, the third series of 8 ends with chlorine, and the fourth series of 18 with bromine, and the fifth series of 18 with iodine.

There was also good evidence that these steps of numbers were associated with the number of electrons in the atom. About 1912 Rutherford suggested that the atom consisted of a heavy central core with a given charge and a number of electrons corresponding to this charge rotating around the central nucleus. Bohr adopted this hypothesis and added the assumption that these electrons rotated around the core with an angular momentum an integral number of times of h (Planck's constant). From this he was able to calculate by ordinary mechanics certain "stationary states" which corresponded to orbits in which the electron was assumed not to radiate. Radiation was assumed to occur

Table I. Periodic Table

Elements in the same verticle line have similar properties. Column subheadings a and b designate two different types of electronic configuration in the outer shell. Under each symbol for the element is its atomic number. Above each element symbol is its atomic weight. Elements with an asterisk above them do not occur in nature in a stable form and therefore no atomic weight is given

GROUP	I a	I b	II a	II b	III b	III a	IV b	IV a	V b	V a	VI b	VI a	VII b	VII a	VIII			0
PERIOD 1	1.008 H 1													1.008 H 1				4.003 He 2
PERIOD 2	6.940 Li 3		9.02 Be 4			10.82 B 5		12.01 C 6		14.01 N 7		16.00 O 8		19.00 F 9				20.18 Ne 10
PERIOD 3	23.00 Na 11		24.32 Mg 12			26.97 Al 13		28.06 Si 14		30.98 P 15		32.06 S 16		35.46 Cl 17				39.94 A 18
PERIOD 4	39.10 K 19		40.08 Ca 20		45.10 Sc 21		47.90 Ti 22		50.95 V 23		52.01 Cr 24		54.93 Mn 25		55.85 Fe 26	58.94 Co 27	58.69 Ni 28	
		63.57 Cu 29		65.38 Zn 30		69.72 Ga 31		72.60 Ge 32		74.91 As 33		78.96 Se 34		79.92 Br 35				83.7 Kn 36
PERIOD 5	85.48 Rb 37		87.63 Sn 38		88.92 Y 39		91.22 Zn 40		92.91 Cb 41		95.95 Mo 42		* Te 43		101.7 Ru 44	102.9 Rh 45	106.7 Pd 46	
		107.9 Ag 47		112.4 Cd 48		114.8 In 49		118.7 Sn 50		121.8 Sb 51		127.6 Te 52		126.9 I 53				131.3 Xe 54
PERIOD 6	132.9 Cs 55		137.4 Ba 56		1389-175.0 La - Lu 57 - 71		178.6 Hf 72		18.9 Ta 73		183.9 W 74		186.3 Re 75		190.2 Os 76	193.1 In 77	195.2 Pt 78	
		197.2 Au 79		200.6 Hg 80		204.4 Tl 81		207.2 Pb 82		209.0 Bi 83		* Po 84		* At 85				222 Rn 86
PERIOD 7	* Fo 87		226.1 Ra 88															
ACTINIDE SERIES					226.1 Ac 89		232.1 Th 90		231 Pa 91		238.1 U 92		237 Np 93	* Pu 94	* Am 95	* Cm 96	-----	----- (103)
LANTHANIDE SERIES					138.9 La 57		140.1 Ce 58		140.9 Pr 59		144.3 Nd 60		* I 61	150.4 Sm 62	152.0 Eu 63		156.9 Gd 64	
RARE EARTHS							159.2 Tb 65		162.5 Dy 66		164.9 Ho 67		167.2 Er 68	169.4 Tm 69	173.0 Yb 70		175.0 Lu 71	

when the electron passed from one of these states to another where the frequency ν of the radiation was given by

$$E_1 - E_2 = h\nu \tag{2}$$

where E_1 is the energy of the electron initially and E_2 its final energy. E_1 and E_2 are referred to as the energy levels of the electron in the atom.

With these assumptions he was able to derive the formula for the line spectrum of the various elements previously given in equation 1. The Rydberg constant R now turned out to be

$$R = \frac{2\pi^2 me^4}{h^3} \tag{3}$$

where m is the mass of the electron and e is the charge on the electron. Values of all of the constants had been known from previous experiments and when substituted in the formula they gave a value of R in very close agreement with that obtained empirically from the spectroscopic experiments.

It will be noted from equation 1 that the number Z, which is the charge on the central nucleus, is an important property of that nucleus. It turns out that it is this charge which is characteristic of any given element and the number of charges on the nucleus is called the atomic number of the element in contrast with the atomic weight which corresponds to the total weight of the nucleus.

In addition to these discoveries another line of research was going on concurrently.

X AND GAMMA RADIATION

In 1895 Roentgen, experimenting with cathode-ray tubes, found that a radiation was emitted when the cathode rays (which are electrons moving with high velocity) fell upon a suitable target, (which was glass in Roentgen's tube, but is one of the heavier metals in modern tubes). This radiation was quite penetrating and could produce a darkening of photographic film even though it completely was sealed in black paper.

Becquerel in 1896 discovered that uranium ore had similar properties in that it gave off rays which produced exposures on films similarly enclosed in black paper. After a long series of tests, the Curies finally separated radium from the uranium ore and it was found to be a source of a radiation very much more intense than the original one.

Roentgen had christened his rays X rays. These could not be deflected by either magnetic or electric fields. Investigations of the radiation from radium revealed three different kinds of rays. One kind was similar to the X rays in their behavior as they were not deflected by an electric or magnetic fields, but the other two kinds were deflected in opposite directions by a given field. Of these, one kind was identified with high speed electrons, which are known as beta particles when emitted from radioactive material. The other proved to be particles much heavier than the electrons and were identified by the name alpha particles. They had a mass very close to the known mass of the helium atom and since have been identified definitely as helium nuclei.

By determining the charge of these particles and their mass by subjecting them to magnetic and electric fields, it was possible to determine their velocity and from that the energy of these particles. This proved to be surprisingly high compared with energies known at that time. For instance, the alpha particle emitted by radium has an energy of approximately five million electron volts.*

Other naturally radioactive materials were found, such as polonium, thorium, and as soon as high energy particles from these sources became available, physicists naturally felt that they might be used to explore the inner core or nucleus of the atom. Previous attempts to explore this nucleus had been unsuccessful because the energies available were apparently not sufficient to penetrate this core.

Rutherford started to use high energy particles from the radioactive elements to determine experimentally the size of the nucleus. This involved scattering of alpha particles by a thin gold foil. The experiments seemed to show that the radius of the nucleus could not be more than about 10^{-12} centimeter which is quite small compared with the radius of the atom which previously had been estimated at about 10^{-8} centimeter.

Many of the gases which Rutherford tested showed very good agreement with a formula which he had derived for calculating this scattering. However, in studying nitrogen, he observed considerable departures from the formula. There were far too many particles with high energy scattered at right angles to the direction of the incident particle than could be explained. Also, particles were found emerging from the reaction with kinetic energies higher than that of the incident alpha particle. This suggested another phenomenon. Investigations showed that the nitrogen nucleus under bombardment by high energy alpha particles was being transmuted into oxygen plus a positively charged particle (hydrogen ion). This particle, a proton, presumably would take with it some of the energy liberated by the reaction. This soon was confirmed by cloud chamber experiments which showed this type of reaction taking place. For the first time the alchemist's dream of transmuting one element into another had been accomplished. The experiment was also important in showing that the proton or hydrogen nucleus was one of the building blocks in the heavier nuclei (nitrogen and helium in this case). Thus, it may be regarded as the discovery of the proton. After

* One electron volt is the energy acquired by an electron when it is accelerated by falling through a potential difference of one volt.

Rutherford's initial success, it was not long before various other elements were disintegrated by alpha particle bombardment and a whole new field of investigation was developed.

It was becoming increasingly clear that while energies of only a few electron volts were associated with chemical reactions, nuclear reactions involved energies of an entirely different order (say, millions of electron volts). This led to a search for machines which would produce particles with energies even higher than those produced by radium and the particle accelerators began to emerge. Best known is the cyclotron* developed by Lawrence at the University of California, Berkeley, Calif., which has gone to higher and higher energies through successive stages. The latest machine built by Lawrence is a 184-inch synchrocyclotron capable of giving deuterons (heavy hydrogen nuclei, that is, hydrogen with a mass number 2) of 200 million electron volts. With these energies, it is now possible to transmute the nucleus of any element in the periodic table in contrast with the work of Rutherford where he only transmuted the nuclei of the light elements because of the limited energy of the particles from radium. In this process of smashing atoms we have enlarged the number of isotopes of the elements. See Table II. However, most are radioactive and do not exist in nature.

The concept of the atom in the early 1920's, after Rutherford's experiments, was that the nucleus was a small core formed somehow of protons which constituted the charge on the nucleus plus some other electrically neutral constituents which made up the difference between the atomic number of the given atom and its atomic weight. Because the two elementary particles known at that time were the proton and the electron, it was assumed that the difference between the atomic number and the atomic mass of the nucleus was somehow a combination of equal numbers of electrons and protons. However, about 1932 Chadwick at Cambridge discovered another particle, the neutron. There had been previous indications that an uncharged particle existed, for instance, when alpha particles were allowed to fall on certain light elements such as beryllium, a very penetrating radiation was obtained. This radiation could be observed in cloud chambers where a single track could be seen starting from a given point but no recoil particle could be identified. The lack of any path attributable to a particle could be thus either the result of a gamma ray (extremely short X rays) or some particle not electrically charged, which would not produce a track in the cloud chamber. By careful experiment, Chadwick showed that it could not be identified with action resulting from gamma rays, but that if it was assumed that there was an uncharged particle, which he called the neutron, with a mass approximately the same as a proton, the laws of conservation of energy and momentum would be fulfilled. The existence of the neutron is now definitely established.

The electron, proton, and neutron are all the building blocks which are used in the modern theory of nucleus. The nucleus is thought to be made up of Z protons, Z corresponding to the charge on the nucleus. If the atomic weight of an element is denoted by A, there are $A-Z$ neutrons in the nucleus as the mass of the neutron is approximately equal to that of the proton. For instance, the symbol for mercury may be written ${}_{80}Hg^{200}$. This denotes that there are 80 protons in the nucleus and 120 neutrons, giving a total atomic weight of mercury approximately 200. It now can be seen why the atomic number is more important in the periodic table than the atomic weight. Mercury has seven isotopes with atomic weight varying from 196 to 204, but all of these are still mercury with the atomic number 80. Platinum with an atomic number of 78 has isotopes with atomic weights of approximately 196 and 198, but these isotopes of platinum can be separated chemically from those of mercury because those of platinum will have all the chemical characteristics of platinum atoms, while those of mercury will have the characteristics of the mercury atom. These elements with different atomic numbers but the same atomic weight, such as ${}_{78}Pt^{196}$ and ${}_{80}Hg^{196}$, are referred to as isobars. This is in contrast with elements which have the same atomic number but different atomic weights as ${}_{80}Hg^{196}$ and ${}_{80}Hg^{200}$ which are called isotopes.

In writing the symbols in this form, for instance ${}_{80}Hg^{200}$, the figure 80 corresponds exactly to Z the atomic number. The figure 200 is called the mass number A and corresponds exactly to the number of protons and neutrons in the nucleus and is approximately equal to the physical atomic weight of that isotope. The accurate atomic weight for this isotope is 200.028 and the difference between this and the mass number is an indication of the binding energy of the atom. The difference often is referred to as the "packing fraction." Another term often used is the "mass defect" which is the difference between this atomic weight and the sum of the masses of the protons and neutrons in the nucleus divided by the latter. Its importance arises in connection with the mass energy relation and is scheduled for discussion in another article in this series.

OTHER ELEMENTARY PARTICLES

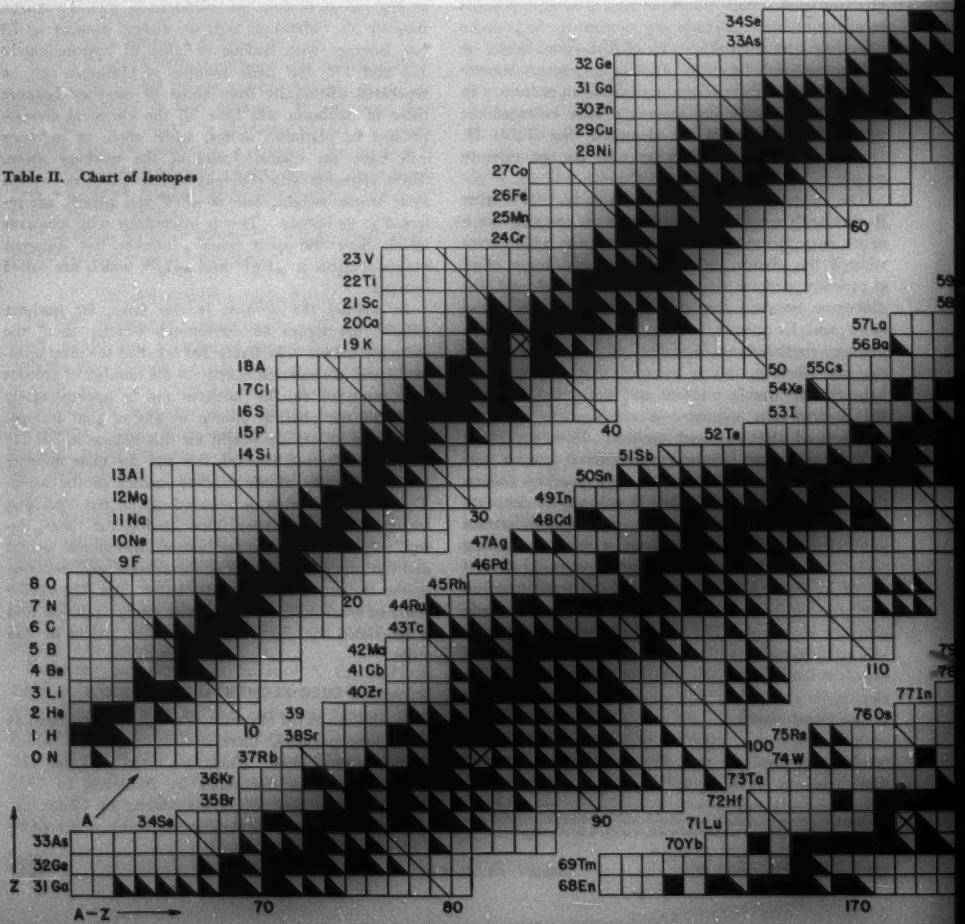
In addition to the electrons, protons, and neutrons, as elementary particles, there are certain others which should be mentioned. These are listed in Table III. The positron was discovered by Anderson in 1932 shortly after the discovery of the neutron by Chadwick. It has the same mass as the electron and is deflected in

* A description of the principle of the cyclotron and other types of accelerators for producing high energies is scheduled for presentation in a later article.

a magnetic or electric field in the opposite direction to that of the electron. One may wonder why it was not discovered at the same time as the electron, and the reason apparently is its very short life. It was discovered in connection with work on cosmic rays where very high energies are involved. As it took a very powerful electromagnet to deflect these particles, it was not until high magnetic fields were available that one could be really sure of the direction of curvature of the path indicating a positive charge. They are of great interest, in connection with cosmic rays and experimental evidence of the creation and annihilation of mass which is scheduled for discussion in another article of this series.

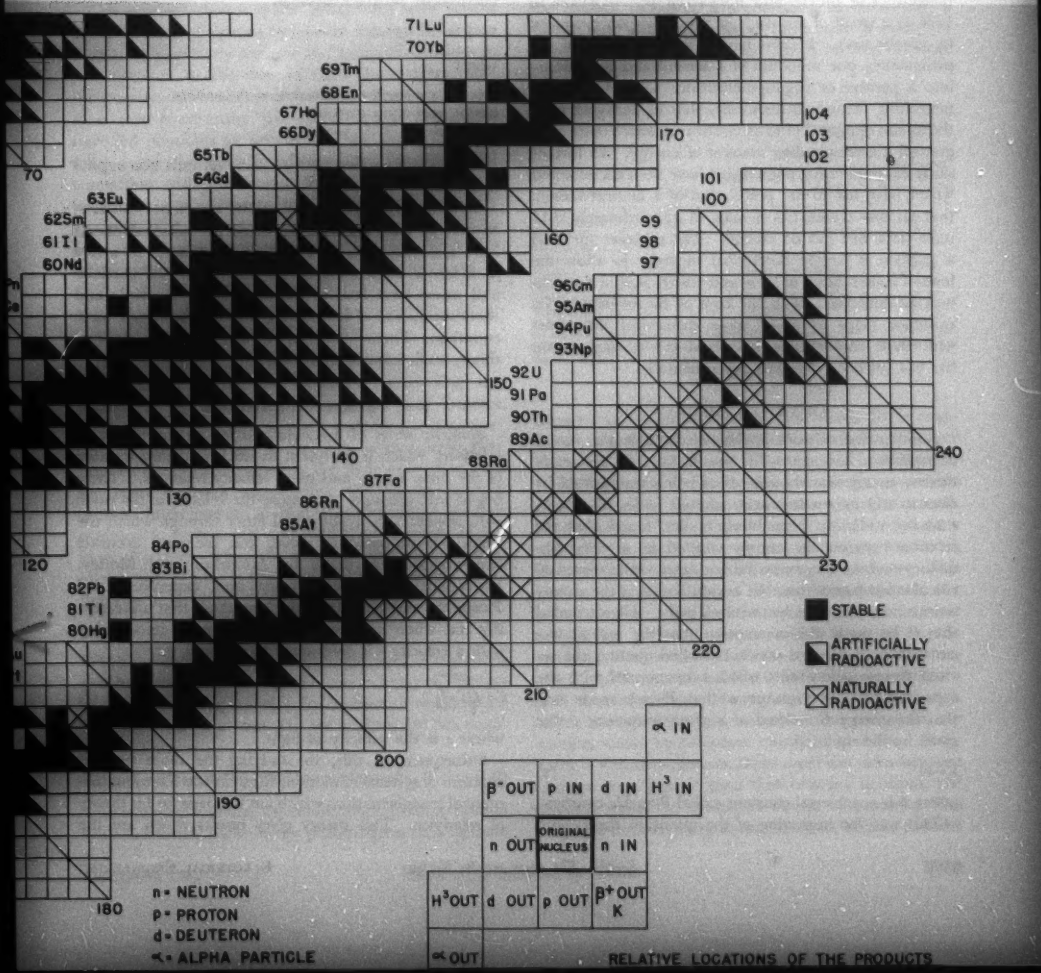
Another elementary particle, the neutrino, has been postulated but not identified to date by direct methods such as cloud chamber experiments or other types of experiments as in the case of the other particles. The evidence for it is mainly theoretical. For instance, if the distribution of energy of beta rays from radium E which have a maximum energy of 1.2 million electron volts is plotted, a distribution curve which shows a maximum number of particles with energies of about 0.2 million electron volts and an average energy of about 0.34 million electron volts results. However, theoretical considerations would seem to say that energy associated with each disintegration of the nucleus should be the same. In order to account for the loss of energy, therefore, it was postulated that this energy was taken up by a neutrino which, if it exists, must bear no charge, as it does not produce ionization in a cloud chamber, and it must be very small and probably has a small

Table II. Chart of Isotopes



mass as it penetrates matter very easily. The advantage of postulating such a particle is that it allows application to these atomic disintegrations of the laws of conservation of mass and energy and the law of conservation of momentum.

The study of cosmic rays has been given a great deal of attention by physicists in recent years although their possible existence has been recognized since 1900. It had been known that no matter how well an electroscope was insulated, it slowly discharged because of ionizing particles in the air. By shielding the electroscope carefully with a heavy shield of lead or other suitable material, the rate of discharge could be decreased and this showed that it resulted from some type of penetrating radiation that was present at the earth's surface. It first was assumed that this might result from the radiation given off by minute amounts of radioactive matter in the earth's surface. On this assumption the intensity of the radiation should fall off rapidly above the earth's surface. Careful experiments made by Kolhorster and Hess and other observers showed that instead of decreasing as they went above the earth, the intensity of the rays increased. As a result of these experiments, they concluded that the radiation came from outside the earth. But if these rays came from outside the earth, it was evident that their energy must be enormous compared with any sources of energy known at that time as they were able to penetrate the entire earth's atmosphere. Further study substantiated this and the present viewpoint seems to be that the primary cosmic rays consists of protons coming in from interstellar space with energy averaging per particle about



10^{10} electron volts and maximum energies of 15×10^{10}. When it is recollected that the maximum energies of particles emitted by radium are of the order of 10×10^{6} electron volts and the maximum energies so far reached in accelerators, such as the syncrocyclotron at Berkeley, are 3×10^{8} electron volts, the very high energies of these cosmic ray particles become readily apparent. Experiments also show that they can be observed more than 600 feet below the earth's surface. The study of the cosmic rays is a very interesting subject and is being given considerable study in order that the mechanism which produces these cosmic rays be understood more thoroughly.

A new particle which has been observed in the study of the cosmic ray is called the meson. It can be charged either negatively or positively and its mass is approximately 200 times that of the electron. It is therefore intermediate in mass between the electron and the proton. The meson was discovered by Anderson in 1936 as a result of the study of the ionization produced by cosmic rays. Mesons have a very short life of approximately one millionth of a second and then decay into a positive or negative electron. One of the most interesting features of mesons is that in decaying from the meson of mass 0.11 to an electron of mass 0.0005, they give off a corresponding amount of energy. In further study of cosmic rays, phenomena have been encountered which have led to the postulation of a neutral meson, that is, one which has a mass of approximately 0.11 mass units but has no charge. The evidence for such a particle is largely theoretical in order to allow the laws of conservation of mass and energy and of momentum be conserved as in the case of the neutrino. Its existence helps to avoid some theoretical difficulties with these conservation laws, but the neutral meson has not yet been detected experimentally.

QUANTUM THEORY

Another line of work having to do with the theory of radiation now must be considered. In the early theory, energy was thought of as being transmitted by electric and magnetic waves. About 1900, Planck, in studying radiation from black bodies, found that the relation between the energy emitted at a given frequency and the frequency did not agree with theoretical calculations based upon the assumption that the energy was emitted uniformly by the black body. He concluded that if he made the assumption that the energy was emitted in small steps which he called quanta, the revised theory gave results which corresponded with the experiment. The assumption that Planck made was that the energy E emitted at a given frequency ν was given by the equation,

$$E=h\nu \tag{4}$$

where h is a universal constant called Planck's constant.

This was the beginning of the quantum theory and later Einstein in 1905 generalized it to apply also to the absorption of energy. He postulated that the energy radiated or absorbed in any process was given by

$$E_1-E_2=nh\nu \tag{5}$$

where E_1 and E_2 are the initial and final energies, ν is the frequency emitted or absorbed, and n is an integer.

Further evidence of the quantized nature of radiation came later in the Compton effect which showed that if it was assumed that the X ray behaved like a particle, then the scattering could be calculated as a problem in dynamics. Conversely, about 1925 de Broglie suggested that particles sometimes might exhibit wave characteristics. This soon was verified by Davisson and Germer who reflected an electron beam from a nickel crystal and showed an interference pattern similar to that produced by light or X rays. This was proof of the wave behavior of electrons and experimentally checked de Broglie's formula,

$$\lambda=h/mv \tag{6}$$

where

λ = the wave length corresponding to the particle
m = the mass of the particle
v = the velocity of the particle

It later was verified that the same formula also applies to atoms.

Thus electromagnetic radiations sometimes must be treated as particles and, in turn, particles sometimes have the properties of radiation. Attempts to arrive at a better understanding of this duality of particles and waves have lead to the uncertainty principle and wave mechanics of Heisenberg and Schrodinger's wave equation. These concepts further modify classical theory to fit experimental facts.

RELATIVITY THEORY

Another series of investigations led to the theory of relativity which is pertinent to nuclear theory because of the mass energy and mass velocity relations. These began with attempts to measure the velocity of the earth with respect to a hypothetical ether through which the earth was supposed to move, and the most accurate experiments were made by Michelson and Morley. Discrepancies between theory and experiment led Fitzgerald and Lorentz to the hypothesis that a measuring rod when moving in the direction of its length l with a velocity v is contracted to a length,

$$l=\sqrt{1-\frac{v^2}{c^2}} \tag{7}$$

where c is the velocity of light.

Subsequent to this, in studying the more general problem of systems in motion, Einstein was led to mathematical transformations which are the basis for his theory of relativity. This theory gives results which are the

same as those of classical mechanics when the velocities of the system are small compared with that of light, but when the velocity of the system is large compared to that of light, the results are quite different. This theory shows that the mass of a body increases with its velocity according to the formula,

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \tag{8}$$

and the kinetic energy of a body in motion is given by

$$E = m_0c^2\left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}-1\right) \tag{9}$$

and the energy of any mass m_0 at rest is given by

$$E = m_0c^2 \tag{10}$$

The original theory made predictions with regard to the bending of light in its passage through the region close to a large body and the reddening of the lines in the spectrum in the case of light from stars whose composition was made up of material which was heavier than that constituting the earth. These predictions have led physicists to believe that the theory of relativity is on the solid foundation. Its importance in connection with the atomic theory is that, in many instances, it is necessary to introduce the relativity concepts of the change of mass with velocity, and so forth, in order to obtain agreement between the results of theoretical calculations and those of experiments.

CHEMICAL REACTIONS AS CONTRASTED WITH NUCLEAR REACTIONS

In chemical reactions we are concerned mainly with phenomena involving the electrons surrounding the nucleus of the atom while the nucleus itself remains unchanged. For instance, when hydrogen and oxygen combine to form water it generally is considered that the two electrons surrounding the hydrogen nuclei and the eight electrons surrounding the oxygen nucleus become interchanged so that these electrons become common to both nuclei and hold them together in the form of water. When the reaction takes place, energy in the form of heat is liberated and the complete equation can be written:

$$H_2 + O = H_2O + 2.93 \text{ electron volts} \tag{11}$$

When we come to nuclear reactions, similar equations can be written, but the phenomenon involves changes in the participating nuclei. For instance, if we bombard lithium ${}_3Li^8$ by a proton ${}_1H^1$, we might write this equation as follows:

$${}_3Li^8 + {}_1H^1 = {}_2He^4 + {}_2He^3 + 3.94 \text{ million electron volts} \tag{12}$$

This equation says that the result of bombarding lithium with sufficiently high energy protons gives us a mixture of helium isotopes ${}_2He^4$ and ${}_2He^3$. In writing such an equation we note that the sum of the atomic numbers on each side of the equation are the same $(3+1=2+2)$ and also the mass numbers or approximate atomic weights $(6+1=4+3)$. In general, our bombarding particle may be an electron, proton, neutron, alpha particle, or X-ray quantum. A more complete discussion of this subject including both production of new elements and the phenomenon of nuclear fission is scheduled to appear in another article of this series.

GENERAL REMARKS

The forces which act between protons and between protons and neutrons are of great interest as they aid in giving a better understanding of how the nucleus is constructed. However, the knowledge of these forces is not of a very satisfactory kind. It is known that the Coulomb law of attraction which says the force between two charges, e_1 and e_2, is proportional to the square of the inverse distance between them and is equal to e_1e_2/r^2, holds reasonably well down to the average diameter of the nucleus which is of about 10^{-12} centimeter. However, below this the Coulomb law no longer holds and some other type of force begins to take place. Furthermore, no Coulomb law exists between protons and neutrons as the neutrons are electrically neutral. From a study of the lighter elements, it is found experimentally that the number of neutrons in any nucleus is approximately equal to the number of protons. This can be seen from Table I where, for example, in the case of oxygen, the atomic number is 8 and atomic weight 16, giving 8 protons and 8 neutrons in the nucleus. This seems to indicate that the largest attractive forces in the nucleus must be forces between neutrons and protons because, if two neutrons attracted each other more strongly than a neutron and proton do, the nucleus would be composed mostly of neutrons. Similarly, if the attractions at these small distances between protons were greater than that between neutrons, the nucleus would be composed mostly of protons. The evidence from such arguments seems to indicate that the

Table III. Particles

Particle	Charge	Mass		Energy Equivalent in Million Electron Volts
		Atomic Mass Units	Grams	
Alpha ($_2He_4$)	+2	4.00388	6.6480×10^{-24}	3727.79
Beta (fast electron)	−1	0.00055	0.9107×10^{-27}	0.51
X-ray photon	0	0	0	
Proton	+1	1.00812	1.6734×10^{-24}	938.56
Deuteron	+1	2.01472	3.3442×10^{-24}	1875.70
Positron	+1	0.00055	0.9107×10^{-27}	0.51
Mesotron (meson)	+1 or −1	0.10970	0.1821×10^{-24}	102.13
Neutron	0	1.00893	1.6747×10^{-24}	939.31
Neutrino	0	*		

* Almost all of the entire evidence for its existence is theoretical. Its mass is less than one-tenth of the mass of an electron and is probably zero.

forces between protons and protons, neutrons and neutrons, and protons and neutrons are very nearly equal. As to what the type of these forces at these small distances between the elementary particles are, the evidence at the present time is not too good. The experimental data at present available are reasonably well satisfied by any rapidly decreasing function as ϵ^{-ar} and a better determination of what the actual form of this function is still the subject of further study.

It may be also of interest to refer to estimates which have been made of the mass of the nucleus considering it to be made up of protons and neutrons. As an illustration to show the various phenomena involved, we may consider the following formula given by Weizsacker:

$$M = NM_n + ZM_p - \alpha A + \beta(N-Z)^2/A + \gamma A^{2/3} + 3/5(e^2/r_0)\frac{Z^2}{A^{1/3}} \quad (13)$$

where

A = the atomic weight
N, Z = the number of neutrons and protons
$r_0A^{1/3}$ = the nuclear radius
M_n, M_p = the mass of the neutron and proton
α, β, γ, and r_0 = empirical constants

The first two terms NM_n and ZM_p would be the mass of the atom if there are no additional forces resulting from the placing of the neutrons and protons together in the nucleus. The third term represents what is known as the binding energy of the particles in the nucleus which is known to be proportional to the number of particles in the nucleus. The fourth term represents the decrease in the binding energy when the number of protons in the nucleus differs from the number of neutrons. The fifth term $A^{2/3}$ represents a surface effect similar to the surface tension which holds a soap bubble together. The last term corresponds to the Coulomb law of repulsion between the protons. Equation 13, when the constants are determined empirically, gives a fairly good picture of the masses of the elements. There are, however, exceptions to it and further work needs to be done in getting a better picture of all the forces which hold the nucleus together.

Another point of interest is the distribution of elements on the surface of the earth and on the surface of the sun. The distribution of the various elements in the universe naturally has been the subject of deep interest because it may provide a clue to how the universe originally was formed and what its trend in the future may be. It is found that the lighter elements are much more abundant than the heavier ones and the abundance decreases uniformly starting with hydrogen and ending with silver. However, from silver up, the curve tends to flatten out. While a reasonably good theory has been evolved to account for the abundances of the lighter elements, none is yet available to explain the constancy of the others from silver up. Also, the source of the energy radiated by the sun now is attributed to the nuclear transformation of hydrogen into helium. This is scheduled for further discussion in another article of this series on the relation between mass and energy.

Since Rutherford's initial success in the transmutation of nitrogen into oxygen, much progress has been made towards an understanding of atomic structure. So far as this has gone, reasonable confidence can be felt in the conclusions, for the theorizing has been checked step by step by experimentation, and convincing confirmation has been found at most of the essential points.

Broadly speaking, the work has lead to a return to an earlier simpler conception of the structure of matter. It no longer appears that there are a large number of individual elements, each distinctly different from the others. All the so-called basic elements have been shown to be formed of different arrangements of the same fundamental units and we know much about the characteristics of these units. Though we have reduced the 92 elements down to three elementary particles—electrons, protons, and neutrons—with a few others, such as positrons, neutrinos, mesons, entering the picture for short times, as they are not stable the relationship between these particles is extremely complex and, in many instances, extremely difficult to measure involving mass, electric charge, velocity, and the like.

There are still many things not known, such as the reason for the very short life of some of these particles, why some isotopes are stable and others not, and what the forces are between elementary particles, such as protons and neutrons at very small distances. In view of the remarkable progress that has been made in the development of knowledge of atomic structure and nucleonics in recent years, it reasonably can be hoped that those parts of the picture which are confused today will become clearer in the not too distant future. It is also equally probable that by that time new experimental observations will have been made which will expose new problems looking for answers.

Appendix. Glossary of Nuclear Terms

The atom consists of a small heavy nucleus approximately 10^{-12} centimeter in diameter surrounded by a largely empty region of 10^{-8}-centimeter diameter in which electrons move somewhat like planets about the sun. The nucleus carries an integral number of positive charges, each 4.8×10^{-10} electrostatic unit in size. Each electron carries a negative charge of the same size, and the number of electrons circulating around the nucleus is equal to the number of positive charges on the nucleus, thus making the total charge of the atom equal to zero.

Proton is a particle with charge 4.8×10^{-10} electrostatic unit whose mass is equal to that of the hydrogen $_1H^1$ nucleus.

Electron is a particle with charge 4.8×10^{-10} electrostatic unit whose mass is 1/1,800 of the hydrogen nucleus.

Neutron is an uncharged particle of approximately the mass of a proton.

Positron is the same as an electron excepting that its charge is equal but opposite to that of an electron.

Deuteron is the nucleus of a deuterium atom. Deuterium $_1H^2$ is an isotope of hydrogen having a mass number of 2, and is present

in natural hydrogen to one part in 5,000. It combines with oxygen to form heavy water.

Meson is a particle with mass approximately 200 times that of the electron. Its life is short, about 1 microsecond, and decays into an electron.

Neutrino is an uncharged particle with mass less than one-tenth that of neutron. The evidence for it is mainly theoretical and it has not been identified experimentally.

Alpha particle is the nucleus of the helium atom and has a charge twice that of the proton and a mass approximately four times that of the proton.

Isotopes are different species of atoms of the same chemical element having the same atomic number but different mass numbers.

Isobars are different species of atoms of different chemical elements having the same mass number but different atomic numbers.

Atomic mass unit is 1/16 the mass of one atom of ${}_8O^{16}$ and equals 1.49×10^{-24} ergs.

Electron volt is the kinetic energy acquired by one electron when it is accelerated in an electric field produced by a difference of potential of one volt. It equals 1.60×10^{-12} erg.

Nuclear structure and nuclear stability. According to present-day views, the nuclei of all atomic species are made up of neutrons and protons. Only certain combinations of neutrons and protons are stable. Generalizing, a nucleus is stable when the neutrons and protons present are few in number, and when their numbers are about equal. As the number of protons increases, the proportion of neutrons required for stability is greater.

Radioactivity and nuclear change. An atom is said to be radioactive when its nucleus disintegrates spontaneously by emitting nuclear particles or radiations. These nuclear particles are

1. *Alpha particle*, a high speed ionized helium atom.
2. *Beta particle*, a high speed electron.
3. *Gamma rays*, electromagnetic radiations similar to X rays. A "particle" or quantum of gamma radiation is called a photon.

Half-lives; the radioactive series. The half-life of a radioactive material is the time required for half the atoms initially present to disintegrate. Often the new nuclei formed are radioactive and there may be several successive generations of disintegration of nuclei until a stable one finally is found. Such a series of disintegrations is known as a radioactive series.

Artificial nuclear disintegration occurs when some element which is normally nonradioactive is caused to emit nuclear particles by bombarding it with some other nuclear particles. The nuclear particles emitted may be neutrons, protons, alpha particles, beta particles, gamma rays, positrons, or deuterons.

Artificial radioactivity occurs when by artificial means an ordinarily stable nucleus is made unstable. This unstable nucleus then will emit some nuclear particle or particles to achieve stability.

Nuclear binding energy is the amount of energy required to separate the constituent particles of a stable nucleus. It is the difference in mass between the total mass of the separate protons and neutrons which make up the nucleus, and the total mass of the stable nucleus. It usually is expressed in ergs, atomic mass units, or electron volts.

Probability and cross section. The probability of a nuclear reaction taking place when an element is bombarded with nuclear particles is expressed by what is called the cross section and is expressed in the following equation:

Number of processes occurring = (number of target nuclei per square centimeter) × (number of incident particles) × (nuclear cross section in square centimeters)

Chain reaction is a nuclear reaction whice emits particles of the same sort that initiate it in sufficient numbers to propagate the same reaction in neighboring nuclei.

Fission occurs when a nucleus absorbs a neutron and splits into approximately equal parts with the release of enormous quantities of energy.

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Liquified Coal for Power

Establishment of great coal liquification and gassing plants with vast new industries by the year 2,000 was predicted by AIEE Past President C. A. Powell (F '41) assistant to the vice-president of the Westinghouse Electric Corporation, in a recent speech on "Sources of Power" before the Rocky Mountain League.

With the exception of atomic energy, present sources of power such as coal, oil, and gas are derived directly from the sun. Of these, at the current rate of consumption, coal alone is available in sufficient quantity to last an appreciable length of time.

The coal of the future probably will be burned as a liquid or gas, and the Pittsburgh Consolidation Coal Company and the Standard Oil Company of New Jersey are planning to experiment with a German method of liquifying coal which has been known to produce 52 per cent gasoline, 26 per cent Diesel oil, 9 per cent wax, and 13 per cent gas. To make up the deficiency of gasoline and natural gas alone by the year 2,000, it will be necessary to liquify more than 900 million tons of coal a year.

Landing Through Overcast

WILBUR T. HARDING
ASSOCIATE AIEE

Landings with visibility less than 660 feet are possible and practicable with well-designed and co-ordinated electronic, lighting, and thermal aids. Commercial air lines well may profit from the tests described.

THE SAFETY attained by commercial airline operators often is expressed upon a basis of passenger miles per fatality. To actuaries or logistically minded individuals these figures are quite reassuring—unless the person involved travels frequently by air. The latter knows that this record has been maintained and realized by sacrificing regularity of schedule and by requiring unscheduled landings at out-of-the-way fields. He also is aware that in the past year there have been a number of fatal or serious accidents attributed to unfavorable weather. If he ponders on this long, he is apt to let a long range weather forecast determine his mode of travel. In so doing, he is activated by two very sound motives. He wants to arrive safely at the airport he chose as his destination and he wants to arrive on schedule.

Landing during adverse weather conditions, although not the only unsolved problem, generally has been recognized as the most troublesome and dangerous. The desirability of correlating electronic and other landing aids is not new. This premise has been accepted and recognized since the first approach-light installation was made using constant rate of descent along a leg of a radio range station. The premise failed in practice when attempts were made to extend the application to more severe weather conditions. It now is known that this failure can be attributed to lack of knowledge of the limitations imposed by the aids used.

While the reports from advance wartime bases in general were highly encouraging, some did come in to indicate that under certain conditions the equipment was not operating as expected. To verify this and to arrive at a corrective solution a test program was established at the Newark Army Air Field. The significant conclusions derived from these tests are

1. Pilots making instrument approaches under actual adverse weather conditions apparently react so as to deviate materially from the ideal approach path or from that which they would follow under the hood with a safety pilot.*
2. The lighting equipment procured upon a wartime emergency basis was found to be designed with too restricted a distribution to be effective with such approach deviations.
3. Present-day transport aircraft are designed structurally so as to impose blind areas thus making the development of suitable lighting equipment more difficult.

It was evident that new developments of wide-angle distribution lighting equipment would have to be

Essential substance of miscellaneous paper 47-234, "Landing Through Overcast," presented at the AIEE Middle Eastern District meeting, Dayton, Ohio, September 23–25, 1947.

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The test program is the outgrowth of combined action of the Army Air Forces, Bureau of Aeronautics, Navy Department, Civil Aeronautics Authority, Civil Aeronautics Board, Airline Transportation Association, and Airline Pilots Association.

* For such tests the pilots' compartment is hooded and a second pilot outside this compartment acts as a "safety pilot."

initiated. As these developments were likely to involve new designs, time, and considerable testing, the test site was moved to Arcata, Calif., selected because of its already installed equipment and its remarkably foul weather record.

EQUIPMENT

In general, there are three types of installations or aids being considered:

1. *Electronic.* The backbone of the landing system is and must be a suitable proved low approach electronic system. The station already was equipped with *SCS-51*, the military version of *ILS* (instrument landing system). In preparation of the test program action was taken to install this equipment in a permanent manner during which the system was rearranged to conform to standard practices with respect to location of components and to operate from commercial power. Even though the installation was well planned and carefully made, variations in the indicated approach path resulted which necessitated the adoption of a monitory and inspection procedure. Regular periodic checks of this equipment were found to be necessary.

The ground installation, together with suitable air-borne receivers, allows the pilot or copilot to follow the indicated approach path to the landing area. Its usefulness is entirely dependent upon the skill of these pilots when approaching for a landing. There is also nothing to prevent such a pilot from departing from the indicated course, if and when he feels that it is justified. If the pilot deliberately flys the beam high to play safe, he may approach over the ground aids at an altitude where these ground aids are ineffective. For such an approach, the ground personnel have no control and often no knowledge of what actually occurs, except that the approach was not successful. It should be apparent that the effectiveness of the *SCS-51* system is dependent upon the pilot following the beam closely to an altitude wherein other aids may assist. Such pilot's procedures must be established by actual approaches in adverse weather and not under the hood with a safety pilot.

In addition to the *SCS-51*, ground controlled approach equipment was secured and installed. By means of this equipment, skilled ground crews follow the aircraft's path by radar and by means of radio communication talk, guide, or direct the pilot along the desired approach path. The effectiveness of the ground controlled approach is therefore directly dependent upon the skill of the ground crew in interpreting their radar scopes and transmitting their interpretations to the pilot. It is also directly dependent upon the confidence with which the pilot implicitly will follow the ground crew's instructions.

2. *Lighting Equipment.* A basic installation of approach and runway lighting equipment was provided. The approach lights were designed and installed, as a result of the tests at Newark and subsequent study by the Army Air Forces. This equipment was intended to allow the pilot to transfer from electronic aids to lighting aids and to complete his landing under contact conditions. The initial installation was designed to be utilized in daytime fogs with zero ceiling and visibility down to one-eighth mile (660 feet).

3. *Dispersal Equipment.* Thermal dispersal installations already had been provided by the Navy Department. These installations were rehabilitated and made operative with the intent that for visibility conditions less than one-eighth mile in daytime, thermal dispersal would be used in addition to the other two aids. In general, two types of installations were available:

(*a*). *Low Pressure.* The initial British FIDO (fog intensive dispersal of) installations used gasoline pumped at a pressure of approximately 50 pounds per square inch at the burners. The installation is arranged to vaporize the gasoline by heat prior to reaching the burners.

(*b*). *High Pressure.* This installation uses either gasoline or oil pressures as high as 1,800 pounds per square inch. The fuel at this pressure is released to atmospheric pressure through a nozzle and vaporization occurs.

TEST PROCEDURES

The test crews assigned were instructed to make numerous approaches under favorable weather, so as to be thoroughly acquainted with the terrain, adjacent radio range, and desired flight procedure.

To eliminate the human equation as much as possible, three motion picture cameras were used to secure film records. Two cameras with colored film were used to cover the field of view through the windshield, as normally seen by the pilot and copilot, respectively. The third camera, with black and white film, was used to record a special instrument panel located outside the pilot's compartment containing an altimeter, rate of climb indicator, *SCS-51* indicator, air speed indicator, gyrocompass, and clock. In the field of view of all three cameras, there was located a small indicator lamp wired in parallel with the marker beacon indicator lamp. Prior to an approach, specific additional data also were recorded upon the same instrument camera, such as date, test personnel, and weather conditions.

To complete the flight test data, additional observers were stationed at the middle marker and at the approach end of the runway. The approximate distance off course and altitude were estimated. During the latter part of the test program, ground controlled approach also was used to monitor the approach path.

CONCLUSIONS

Successful daytime landings were accomplished with reported visibilities as low as 400 feet. Visibility conditions of 660 feet or above were considered practicable. Similar landings at night were relatively easy because of the lack of background brightness. The additions of thermal assists in clearing the landing area made possible landings under more severe weather conditions.

In applying the results of tests to date to the problem which confronts commercial aviation, certain conclusions appear to be self-evident:

1. Regularity of schedule and safety of operations under adverse weather conditions with minimums far below that now being practiced can be attained by

(*a*). Use of equipment designed for the intended service.

(*b*). Proper installation of all the necessary equipment—electronic, lighting, and thermal.

(*c*). Proper training of operating personnel to depend upon and to use the installations provided.

2. To apply these principles properly, airport design and practices must be modified:

(*a*). The location of an airport with respect to the center of the city it serves should not predominate if that selection is made at the expense of a needed facility. For example, an airport having its principal approach over water with no area for electronic or visual approach aids ultimately will be discarded for one that can have all the essential aids.

(*b*). Electronic and visual aids must be designed and installed as a correlated installation.

(*c*). Control procedures must be developed to reduce stacking time and to expedite the approach procedure.

The 500-Kv Tidd Test Project

Increasing attention is being given to the subject of power transmission at higher and higher voltages because of the economies that can be effected by so doing. The Tidd test project has been organized to obtain much needed information that will help make such transmission practical.

PAST EXPERIENCE and an analytical examination of the economics of transmitting increasingly larger blocks of power indicate the desirability of going to higher voltages than have been used heretofore. However, the cost of building a transmission system increases rapidly with increasing voltage. The use of increased voltages requires effectively larger conductors, larger towers, higher insulation levels, and more expensive terminal equipment. These factors make it important to evaluate carefully and precisely all engineering factors entering into the design of higher voltage transmission systems. Precise and reliable data on the characteristics and performance of materials and equipments constituting the transmission system are very necessary.

Recognizing the need for additional information on this subject, the American Gas and Electric Service Corporation invited a number of manufacturers to cooperate in a research and test program on extra-high-voltage power transmission. A site was chosen, on a flat stretch of land about $1^1/_2$ miles long, along the Ohio River, adjacent to the Tidd plant at Brilliant, Ohio. A full-sized test line with associated equipment designed to operate at 500 kv was constructed, and several companies are participating in the high-voltage tests.

The Westinghouse Electric Corporation contributed the power transformers, lightning arresters, and measuring equipment, and also has been active in planning the investigation. The American Bridge Company has contributed the towers, and the Ohio Brass Company and Locke Insulator Corporation, the insulators and hardware. The Aluminum Company of America, General Cable Corporation, and Anaconda Wire and Cable Company have supplied the conductors. The General Electric Company is supplying an oil circuit breaker and arrester. Also participating in the project are the Ohio Power Company, Appalachian Electric Power Company, Indiana and Michigan Electric Company, Wheeling Electric Company, Kentucky and West Virginia Power Company, Inc., and Kingsport Utilities, Inc., subsidiaries of American Gas and Electric Company.

DESIGN FEATURES

A number of interesting design features are embodied in the test project. Three parallel test lines constitute the transmission system. They are connected directly to a bus at the test station without circuit breakers and are fed through a 5,000-kva bank of three single-phase transformers. Three single-pole arresters have been installed to protect the transformer. An oil circuit breaker, protected by an arrester, will be connected to the bus. Measuring instruments are mounted on the top of the transformer bushing which will be read by telescope from an observation booth some 50 feet distant.

Within the test station all bus work is of 2-inch segmental hollow conductor. Shielded measuring leads are enclosed within the hollow conductors and extend from the instruments in the housing box on top of the high-voltage transformer bushing to the entrance of each of the three lines.

Two of the three test lines are 1.4 miles long, and the third is a single 800-foot span. The two longer lines have an average span of about 1,050 feet and comprise seven towers per line. Two of the towers on each line are dead-end, one at the far end, and the other is the second tower out from the station where the lines change direction 28 degrees. The lines run approximately parallel and about 288 feet apart, center-to-center. The line conductors are approximately 85 feet above the ground at the towers and about 40 feet at midspan. Provision is made on all three lines for the installation of two ground wires at variable spacings above the conductors with a maximum elevation above conductors of 40 feet. The ground wires also extend over the station for bus and equipment shielding. Line towers are provided for variable conductor spacings of 45, $38^1/_2$, and 32 feet between conductors. The lines are phased so that adjacent conductors of different lines connect to the same phase.

TRANSFORMERS

Three single-phase transformers are used to step up the 66-kv supply to high voltage that can be varied between 264 and 500 kv, line-to-line. The transformer bank is delta-connected on the 66-kv side and Y-connected and solidly grounded on the 500-kv side. They were built in accordance with the design principles that

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Based on information contained in the following technical papers: **47-241**, "Transmission of Electric Power at Extra-High Voltages," P. Sporn, A. C. Monteith; **47-242**, "Corona Considerations on High-Voltage Lines and Design Features of Tidd 500-Kv Test Lines," C. F. Wagner, A. Wagner, E. L. Peterson, I. W. Gross; **47-243**, "Insulators and Line Hardware for Tidd 500-Kv Test Line," I. W. Gross, R. L. McCoy, J. M. Sheadel; **47-244**, "Line Conductors—Tidd 500-Kv Test Lines," E. L. Peterson, D. M. Simmons, L. F. Hickernell, M. E. Noyes; **47-245**, "Transformers and Lightning Arresters—Tidd 500-Kv Test Line," F. A. Lane, J. K. Hodnette, P. L. Bellaschi, E. Beck; **47-246**, "Switchgear Equipment for Tidd High-Voltage Test Line," F. A. Lane, B. W. Wyman; and **47-247**, "Instrumentation and Measurement—Tidd 500-Kv Test Lines," R. L. Tremaine, G. D. Lippert. These papers were presented at the AIEE Midwest general meeting, Chicago, Ill., November 3–7, 1947. Appreciation also is expressed to I. W. Gross of the American Gas and Electric Service Corporation, and the Westinghouse Electric Corporation for assistance in the form of information and photographs.

would be applied to commercial high-voltage power transformers. The impedance is 6.6 per cent which is low compared with power transformers of comparable size or compared with a testing transformer. This is of advantage in maintaining a sinusoidal wave shape.

The windings of the transformer are arranged in the manner normally used in the design of high-voltage shell-form transformers except for the large tap range to provide the high voltages from 265 to 500 kv. This range was obtained by using a standard 10 per cent tap range in the high-voltage winding and providing a large range of taps in the low-voltage winding. These taps are brought to no-load tap changers operated from hand wheels on the tank wall. The total tap range is covered in 24 steps, the low-voltage tap changer providing large steps with the high-voltage tap changer acting as a vernier.

The transformers are provided with standard accessories including inert gas protection, oil gauge, oil thermometer, and manhole relief and oil valves. A unique feature is the provision for a voltage metering winding at high-voltage line potential. This is obtained by extending the high-voltage winding for a few turns and bringing the lead through the bushing with the main line lead. This portion of the winding and its lead is electrostatically shielded so that it does not carry appreciable capacity current thus avoiding errors in metering from this source. This winding provides a voltage for metering and power for the other equipment mounted in the cabinet at the top of the high-voltage bushing. In addition, conventional metering windings are provided on the core at a low-voltage level. The transformers may be seen in Figure 1.

LIGHTNING ARRESTERS

Two different types of lightning arresters have been installed in the test station. They may be seen in Figure 2, on either side of the observation booth. Both are electrically alike, the maximum voltage rating being 359 kv. The arrester at the right of Figure 2 is designed for suspension from a steel structure. The units are suspended in zigzag fashion between strings of insulators. This shortens the length considerably below the length required if the units were all arranged in line. At the left in Figure 2 may be seen a self-supporting arrester. It requires no bracing but it is more complicated and more bulky a structure than the suspended arrester. There are advantages and disadvantages in each. The suspended type may be preferred in certain regions because it is less likely to be damaged by earthquakes, and the self-supporting type may be preferred when supporting structures are not available. Grading rings are used to control the electrostatic field so that the voltage impressed across the arrester terminals will be divided uniformly between the units.

LINE TOWERS AND SUBSTATION STRUCTURES

There are 15 transmission line towers and 9 substation structures in the test installation. Two of the test lines

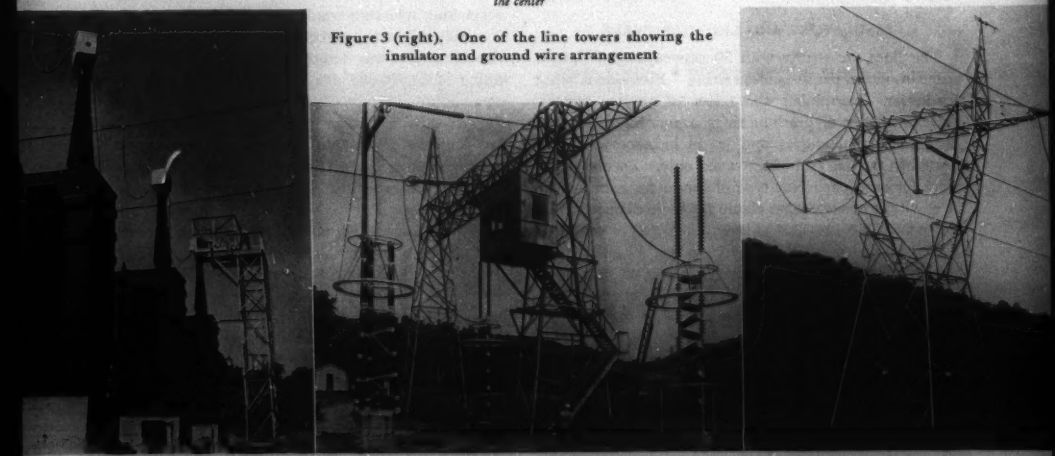
Figure 1 (left). Three single-phase transformers having a bank rating of 5,000 kva supply power to the 500-kv test lines

The movable steel platform is used to service metering equipment in the boxes on top of the transformer bushings

Figure 2 (below). Lightning arresters installed to protect the power transformers

The self-supported type is shown at the left and the earthquake-proof or suspension type is at the right; an observation booth is in the center

Figure 3 (right). One of the line towers showing the insulator and ground wire arrangement



contain seven towers each in addition to the substation take-off structures. Five of the towers in each of these lines have suspension insulator attachments and two have strain attachments, one of which is located at the terminus of each line and one at an angle point in each line. The third line consists of a single 800-foot span, and it contains a special type of strain tower in addition to the substation structure forming one support of the stand.

The line towers support three conductors, 100 feet above the ground at the point of attachment of the insulator strings, and two ground wires located 24 feet above the conductor crossarm. The conductor crossarm is 90 feet long, providing a maximum phase spacing of 45 feet. Attachments are provided on the crossarm so that the outer conductors can be moved toward the center of the tower to provide alternate phase spacings of 38½ feet, and 32 feet. Alternate attachment points for the ground wires are provided so that the wires can be lowered 6 or 12 feet below the normal topmost location. These suspension towers were designed for average tangent spans of 1,200 feet.

The substation structures are essentially similar to the line towers except that the height and crossarm lengths are less. Three of the structures support the incoming line conductors as well as the bus cables together with ground wires. The remaining substation structures support busses and station ground wires only, except one combination tower and cross girder structure which supports two suspended lightning arresters in addition to the busses and ground wires. The latter structure also has attached to it a steel frame observation booth to be used for the visual observation of the measuring equipment and for various control devices. A substation structure is shown in Figure 2, and one of the towers may be seen in Figure 3.

INSULATORS AND LINE HARDWARE

The lines are strung with 30 conventional 5¾-inch space insulators per suspension string. Provision is being made for determining the effect of shorter strings. Different types of grading rings are provided by the insulator manufacturers and in all instances are connected to the line end of the string only. Special hardware for each particular type of conductor is provided. A new type of suspension clamp for large diameter conductors was developed that is almost 40 per cent shorter than conventionally designed clamps. A preliminary study indicated that there appeared to be no advantage in attempting to develop any special insulator or to use any intermixing of various insulator sizes or shapes in the string. Therefore the conventional ball and socket 5¾-inch spaced unit was decided upon. It is possible to remove or short-circuit out insulators in the line to study the effects of corona with a lesser number of units.

The corona shield, involving a novel means of support, completely shields the hardware at the lower end of the insulator string. Tests have indicated that the 2-inch diameter material used for the corona shield gives adequate corona suppression.

CONDUCTORS

The line conductors now installed are 1.65-inch outside diameter, segmental copper conductors on one line; 2.0-inch outside diameter *ACSR* (aluminum cable steel reinforced) with paper filler on the second line; and 1.65-inch outside diameter stranded copper with I-beam core on the short line. It is planned to use a smaller single conductor segmental copper, and the "bundle" or group conductor later in the tests on the short line.

Early investigations of corona initiation voltage and loss on bare transmission line conductors suggested theoretical and practical advantages in splitting large conductors into groups of smaller subconductors. While the group conductor construction is not a new idea, it has not been used commercially for power transmission purposes in the United States. To determine the optimum number, diameter, spacing, and arrangement of cables when grouped, it is planned to make preliminary investigations with installations on the third test span. These investigations will include alternative arrangements with two, three, and four conductors of two different diameters and spacings of 6 to 18 inches. To effect these changes, special hardware has been designed, consisting of adjustable dead-end assemblies for the conductors and adjustable spacers to maintain separation of the conductors in the span if necessary.

SWITCHGEAR EQUIPMENT

In developing a circuit breaker to meet the requirements of the Tidd test line, it became apparent that the supporting structure would be of such dimensions that it readily might serve other purposes. The experimental circuit breaker was designed for a 3-phase interrupting rating of 10,000,000 kva at 360 kv. It is the low oil content impulse-type breaker, originally developed for the 287-kv transmission line between Hoover Dam and Los Angeles. To obtain higher speed reclosing on this new high-voltage circuit breaker, a compressed air mechanism was designed to replace the motor-charged spring mechanisms used on earlier circuit breakers of this type. The operation of each pole by its own mechanism permits either 3-pole or single-pole reclosing. Tests have shown that these mechanisms are adjustable to reclose the circuit breaker in ten cycles, or less, if that should prove practical from a dielectric recovery standpoint of the arc path. Figure 4 shows a single-pole unit of the circuit breaker set up for operation test. The large shielding rings at either end of the horizontal interrupting tube divide the voltage uniformly between the breaks.

The arresters installed to protect the switchgear equipment consist of standard station-type thyrite interchange-

able 12-kv units of the type used on many high-voltage systems. The arrester consists of 25 units, and has a maximum permissible line-to-ground rating of 300 kv.

INSTRUMENTATION AND MEASUREMENT

The instruments for measuring corona loss are mounted in an aluminum box located on top of the transformer high-voltage bushings. Figure 5 shows a close-up view of the instrument box. Power for the instruments will be provided by an extension of the main winding of the transformer at the high-voltage end. This extension not only supplies the power to the voltmeter and potential coils of the instruments, but also power for auxiliary equipment such as lights, rectifiers, controls. The corona loss is measured directly by wattmeters with current coils in series with the line. Power is measured by indicating instruments observed through a telescope from an observation booth located approximately 60 feet away. Measurements can be recorded over long periods of time by graphic meters. Slow-moving meters integrate effects over long periods of time, and a high speed meter permits study and co-ordination of loss under abnormal weather conditions. The measuring equipment may be controlled remotely from the observation booth. Various measuring instruments to record atmospheric conditions will be provided, such as a graphic thermometer, barometer, hygrometer, precipitation meter, and an instrument for measuring ground gradients which may influence corona.

An important phase of the tests will be the measurement of radio noise originating in the transmission line as a result of corona. Radio-frequency traps have been installed in each line to confine disturbances originating within the substation area and prevent propagation into the line on which measurements are being made.

SCOPE AND OBJECTIVES

The test setup has been planned with the idea of making corona measurements on a full-scale transmission line energized by a full-sized transformer and other equipment, closely similar to what would be used in extra-high-voltage transmission. Attention will be directed initially toward:

1. Conductor sizes ranging in diameter up to two inches in both the segmental and wire form will be tested. Group conductors consisting of 2, 3, and 4 wires, smaller in diameter than if only one per phase were used, and spaced at distances in the order of one or two feet, will be tested also.

2. The number of insulators will be varied up to a maximum of 30 per string.

3. Lateral spacing of conductors in flat configuration will be changed.

4. Height of ground wires will be varied in several steps, and the effect of the presence and absence of ground wires under identical weather conditions will be determined.

5. Conductor weathering will be studied.

6. The effects of atmospheric conditions such as rain, fog, sleet, hail, and snow, on extra-high-voltage operation will be investigated. Interpretation of results will be facilitated by recording the loss over long periods of time.

7. Electric ground gradients and their variation with rain clouds, and also their influence upon corona, will be studied.

8. Insulator loss as affected by fog, sleet, and rain will be studied.

9. The effects of all these factors on radio reception will be determined. In particular, the conditions at the tower will be given careful attention.

The responsibility of the tests lies with the engineer who are associated with the American Gas and Electric Service Corporation.

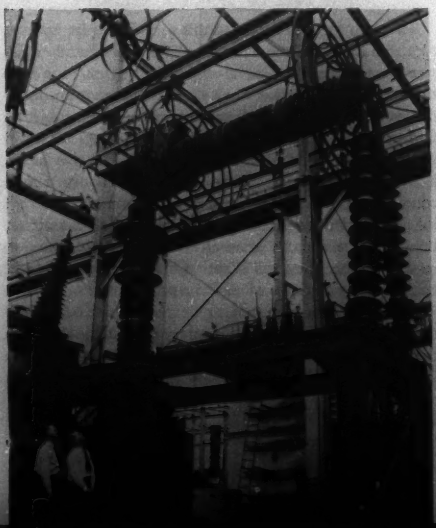


Figure 4 (left). A single-pole unit of the circuit breaker

Three of these will be used in the final installation

Figure 5 (below). Close-up view of the instrument box

These instruments will be read by telescope from the booth shown in Figure 2

Training English Teachers for Engineers

W. GEORGE CROUCH ROBERT L. ZETLER

Still another idea is added to the growing list of suggestions for improving the engineering curriculum. The authors, both teachers of English, suggest setting up a special graduate training program for potential teachers of English in engineering schools. Such a program would produce the ideal instructor—a teacher who is trained both in engineering and in English.

THE editor of any technical magazine knows that out of the hundreds of manuscripts he receives each year, many will have to be rejected. Although some of these may be based on original ideas and careful research, they are not accepted because the writers lack the skill to set down what they have to say in well-organized, concise, and lucid prose. The editor is forced to conclude that too many engineers do not know how to write.

Since most of them have had at least a year or two of English in college, presumably they should be well trained in the composition of an article or a report. Most are not. Why?

STUDENTS' AND INSTRUCTORS' ATTITUDE

The majority of engineering students do not learn English because they are conditioned against it from their freshman year. The reasons are plain to anyone who has taught the subject to them.

The student himself, intent on getting technical information as quickly as possible, is impatient with any course which does not contribute directly to the desired end. Although he knows that after graduation he will be responsible for a certain number of letters, he is sure that he will be able to turn them over to the "blonde" in the office.

Conscious of this attitude and unaware that he can do anything to combat it, the English instructor—usually a youngster from the college of liberal arts—may be overcome by a feeling of futility and merely go through the motions of a teaching routine. Even though some instructors want to help the student master composition, they have little success because they know nothing about engineering.

Too often even teachers of engineering subjects are indifferent to the problems of oral and written expression. By implication they encourage the student to neglect his English training and to concentrate on technical studies.

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The whole situation is unfortunate. So long as the English teacher maintains his present attitude and the engineering student his special point of view, no improvement can be expected. Engineering students (as they should) always are going to have their major interests in technical subjects; like most students in professional schools, they always are going to have a practical outlook on life. But they can be converted from their antipathy to English by a new type of teacher. Why should they not have as instructors men who have been trained both in engineering and in English?

Unfortunately there are few men of this sort available, they are rare birds on this earth, much like black swans. To increase their number, special graduate training for potential teachers of English in the engineering schools ought to be set up. No such training is offered by our graduate schools at the present time.

To set up such a plan involves three major factors:

1. The selection of the right kind of men to be trained.
2. The organization of the whole program in the graduate school.
3. The determination of the emphases of the new curriculum.

NEW TYPE OF TEACHER NEEDED

The men for a program of this sort should be graduates who have had the basic curriculum in general engineering. The should *not* be majors in English from the college of liberal arts. They should be men who have demonstrated their excellence in engineering subjects and who have shown marked ability in using the language. Aptitude tests should indicate whether they have a living interest in teaching. Interviews between the candidates and professors in both the school of engineering and the department of English, as well as an examination of the candidates' general academic record, should reveal whether they will want to make the teaching of engineering communications their profession.

If men of this type are to be recruited as English teachers, they must be paid a salary equivalent to what they might expect as young engineers starting in industry. Otherwise, they will not want to spend the time neces-

sary to prepare themselves for teaching. As an inducement to stay in the profession, they must be offered the same opportunity for advancement as that given the teachers of regular engineering subjects. Only by meeting these conditions can an engineering school hope to obtain and hold men of the proper type.

"ENGINEERING COMMUNICATIONS"

To give such men the highly specialized training they will need, a new curriculum will have to be introduced into the graduate school. Because the number of teachers needed in "engineering communications" will be relatively small, the new program should be restricted to a limited number of schools. To induce one or two outstanding universities to establish this curriculum will be difficult. Deans of graduate schools, like mother hens, jealously watch over their curricular "flock." They will resent the introduction of any such ugly duckling as graduate training in engineering communications for students who have majored in engineering. They have been accustomed to think in terms of at least 24 semester hours in English as a minimum requirement for admission to graduate work in that department. This is the law, fixed, unalterable, more sacred than the commandments.

GRADUATE SCHOOLS MUST CO-OPERATE

If the dean of any graduate school can be persuaded to introduce a new curriculum designed to train teachers for engineering communications, he will have to determine what division shall have jurisdiction over it. Shall it be the school of education, the school of engineering, or the department of English?

If this training is to be placed where, upon first thought, it seems to belong—in the English department—it will be subject to several limitations. Because the English department in any university has complete control over composition, it naturally will want supervision of the new curriculum. But an English department is concerned primarily with aesthetics. The men in it are usually unsympathetic to the engineering student and his practical aims. They know little about the subject matter of engineering types of writing; they care less. On the other hand, they do know the techniques of writing, and they have had experience in teaching those techniques.

If this curriculum is taken over by the graduate division of the school of engineering, it is just as probable that the technically trained man will not be any more sympathetic to its aims than his colleagues in the English department. He will be limited by his lack of detailed knowledge about English and its teaching. His training may prejudice him against the waste of what he feels to be a good engineer. For these reasons, he and his fellow engineering teachers should not have exclusive charge of the prospective teaching group. Yet they know what the engineering student will need to write after leaving college. They know the engineering frame of mind; they should have valuable suggestions concerning the training of men who are later to teach engineering students.

The placing of this curriculum under the control of the graduate division of the school of education is also possible. The average school of education, unfortunately, is notorious for its undue emphasis on "methods" courses, rather than on the materials to be taught. Its professors are isolated from the problems of the engineer, particularly as they are accustomed to train teachers for elementary and secondary school work. Yet perhaps the school of education ought to be the division to supervise this new curriculum. Some training in methods of teaching is necessary. It is not enough to know subject matter alone; one also must know how to teach it. Professors of education who have devoted much time and thought to methods will have a great deal to offer the candidates who are later to go into engineering schools as teachers of English. Since the school of education is not concerned directly with the subject matter of either English or engineering, its professors will be able to evaluate the requirements for this new type of teacher.

The success of the new curriculum, however, will depend on the willingness of professors of education to cooperate with professors in the school of engineering and the departments of English and speech, as well as with practicing engineers in industry. A curriculum worked out by the co-operation of all these should result in the proper kind of training.

EMPHASES OF NEW TRAINING

Granted that this co-operation can be effected, what points of emphasis should such training have? It should give the prospective teacher a thorough knowledge of the field in which he will be teaching. It should equip him with the techniques needed for communicating his information to others.

The conventional training of the average graduate student in English today aims to develop a scholar who will know research methods. It stresses philology and requires a knowledge of English and American literary history, as well as specialization in some particular period of literature. Such specialization is not suited to the preparation of a skilled teacher of engineering communications. He needs instead a knowledge of English grammar and the principles of composition as applied to technical writing. He should have an over-all acquaintance with his own, and with English literature; he should have a broad knowledge of contemporary literature of the sort the engineer will need and want after he leaves school. He should understand the principles of literary criticism. He also should be expected to know bibliography in both the technical and the literary field. He should be well informed on developments in scientific and technical writing, so that he will be able to stimulate his students to read. By his

own contributions to the technical journals, he should show that he can put into practice the principles he is teaching.

A certain number of courses concerned with teaching methods should form part of his graduate education. He should be required to take part in conferences relating to the teaching of English to engineering students—conferences at which experienced teachers of English and speech as well as teachers of engineering and education will be present. Special lectures and discussions by practicing engineers from industry ought to supplement this work. As an aid to his thinking and reading, he should have access to a good library of engineering publications and magazines concerned with the subject material of English courses and the techniques of teaching. To find whether he can apply what he has learned, he should have opportunity for practice teaching under the guidance of skilled teachers of English and speech, as well as professors of engineering and education, who can give him constructive criticism. He may serve as a cadet teacher, aiding and observing instructors.

CONCLUSIONS

Training of the sort just outlined will be costly, for it will involve the services of specialists from different fields, but if it produces teachers who have knowledge of engineering communications, it will be worth all the money put into the plan.

The results of this projected program should be that:

1. The teaching of English to engineering students will be made more efficient and productive.
2. There will be a closer relationship between the teacher and the student because each will share the other's interests.
3. The students themselves will have a greater interest in technical writing and wide reading.
4. The students will master oral and written communication to a greater degree than under the present system, and those who enter industry will be of greater value to the companies for which they work.

The teacher trained both in engineering and in English should be able to vitalize engineering communications to such a degree that his students will look upon English as indispensable to their professional advancement.

The Proposed Colorado River Developments

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THE Colorado River is a muddy stream that constitutes the lifeblood of the Pacific Southwest, the most important feature of which is the ultimate scarcity of its water or its ultimate inability to supply the potential needs of the communities dependent on it for irrigation and domestic water supply. The next feature of importance is the potential power capability of the river and its relation to the power needs of this same Pacific Southwest area.

The interests of Nevada in the Colorado River are represented by some relatively small allocations of water for irrigation and in having sufficient electric power to develop the natural resources of the state, and to take care of the natural growth of power needs of the state. Arizona's interest in the Colorado River is to provide for a supplemental supply of water for recently developed irrigated lands which now are making an overdraft on the underground reservoir and to provide for some expansion of agricultural development. Arizona also has an interest in preserving the extensive present irrigation developments on the Salt River and Gila River, which are a part of the Colorado River basin and are related intimately to its water problems. Arizona, also, has a need to obtain sufficient electric energy to supply its normal increase in power demands.

Approximately one-half of California is partly or wholly dependent on the Colorado River for a water supply for irrigation, domestic, and industrial purposes, and also looks to the Colorado River for a substantial part of its electric power supply with consequent saving of more than 15 million barrels of oil annually. As a

Essential substance of a conference paper "Important Engineering and Economic Features of the Proposed Colorado River Developments," presented at the AIEE Pacific general meeting, San Diego, Calif., August 26–29, 1947.

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consequence of contracts consummated on the occasion of the construction of Hoover Dam, approximately one million acres of land in the Palo Verde, Imperial, and Coachella Valleys are dependent on the Colorado River for irrigation and domestic water supply. Approximately one-half of this land is developed at present.

Looking toward the formulation of a plan for comprehensive development, the "Comprehensive Report on the Colorado River" presents for consideration "134 potential projects or units of projects, mostly multiple purpose, for use of water within the natural drainage basin of the Colorado River. Potential projects for the export of water from the Colorado River basin to adjacent basins are also discussed."

Important engineering and economic features of the proposed Colorado River developments will determine which of the 134 projects are built. Co-ordination of the use of water in the entire basin is necessary if the best and most necessary use is to be made of the river's resources.

Figure 1 shows a simple map of the upper and lower basins of the Colorado River. The river flows for a distance of approximately 1,400 miles in a southwesterly direction from the Rocky Mountains to the Gulf of California. The drainage basin includes an area of 242,000 square miles within the United States, which is 1/12 of the entire area of the United States.

The river basin includes extremes of year-round snow cover in the Rockies and extreme desert conditions in the Yuma area. Maximum precipitation in the basin, from 15 to 30 inches annually, is found in western Colorado. The second area of heaviest rainfall is found in central Arizona where the annual precipitation ranges from 10 to 20 inches. The portions of Wyoming and Utah within the basin provide precipitation ranging from 5 to 15 inches per year, and the extreme southern desert portion has an annual precipitation of approximately 5 inches per year. The average rainfall for the entire basin is approximately 15 inches, and less than 10 per cent of this rainfall appears as actual runoff as virgin flow of the stream.

All of the water of the upper basin funnels into a stretch of the main river near the Utah–Arizona state line. Lee Ferry, Ariz., one mile below the Paria River, has been chosen as the dividing point between the upper and lower basin. Of the long-term average of 16,270,000 acre-feet of water available at this point, approximately one-half is from the Grand River in Colorado, one-third from the Green River, and one-sixth from the San Juan River.

Between Hoover Dam and the Gila River, the inflow from tributaries amounts to more than one million acre-feet, but is offset by evaporation and seepage so that the flow of the Colorado River at the Gila River is only slightly different from that estimated at Lee Ferry. Under virgin conditions the Gila River contributed an average flow of 1,270,000 acre-feet, which brings the estimated virgin flow of the Colorado River at the international boundary up to approximately 17,700,000 acre-feet.

The use of water on present and presently authorized projects in the upper basin, including diversions to adjacent watersheds, is 2,756,000 acre-feet, which represents a duty of approximately $1\frac{1}{2}$ acre-feet per acre of irrigated land. Potential projects, outlined in the report, would increase this use by 6,381,000 acre-feet, leading to a total ultimate consumptive use in the upper basin, if all projects could be built, of 9,136,000 acre-feet.

In the report the use of water on present and presently authorized projects in the lower basin, including so-called diversions to the Imperial Valley area, is 8,500,000 acre-feet. Potential projects outlined in the report would increase this use by 2,560,000 acre-feet, leading to a total depletion of 11,060,000 acre-feet.

Therefore, the total use of water in the basin, if all potential projects were built, would be nearly 20,200,000 acre-feet. In comparison with the flow of the river available after making allowances for the delivery of 1,500,000 acre-feet per year to Mexico, it is evident that the aggregate for the projects exceeds the estimated amount of water available by at least 25 per cent.

If all of the 134 potential projects could be developed, the new land that would be brought into cultivation would be 1,230,810 acres in the upper basin and 303,150 acres in the lower basin, while a supplemental supply would be made available for 504,170 acres in the upper basin and 618,100 acres in the lower basin.

The total hydroelectric development presently in the upper basin is 57,217 kw, of which about 87 per cent is on the Grand River in Colorado. The potential projects in the upper basin would add 1,713,000 kw and develop 9,241,000,000 kilowatt-hours. In 1943 the installed generating capacity in the upper basin was 101,082 kw, with a production of 330,149,000 kilowatt-hours, or less than six per cent of the total potentialities.

The upper basin power plants are not, in general, large ones. The developments on the Green River include 11 plants having a total capacity of 460,000 kw, of which the Echo Park plant of 120,000 kw is the largest. On the Grand River seven plants have a capacity of 228,000 kw of which the largest is Dewey with 140,000 kw. In the San Juan division eight plants have a capacity of 965,000 kw, and the largest is that at Glen Canyon with 400,000 kw and at Dark Canyon with 350,000 kw.

Obviously, if the developments are made, the power must be transmitted out of the upper basin, which involves exceedingly long transmission lines to the markets. Only one of the upper basin power developments, that at Glen Canyon, near the Utah–Arizona state line, is

apparently suitable for supplying the Southern California area. The transmission distance for this project is nearly 500 miles.

The present total hydroelectric development in the lower basin is 1,258,030 kw installed with planned capacity to be added to bring the total to 1,838,000. The potential projects proposed for the lower basin would add 1,945,400 kw and develop 10,205,000,000 kilowatt-hours. The present demand in the area is approximately 2,500,000 kw and is doubling every ten years.

Figure 1. Colorado River basin

It thus becomes evident that the addition of presently planned capacity plus the potential new capacity plus that portion of the upper basin within economic transmission distance represents a gain of nearly 3,000,000 kw, which is less than 15 years' growth. The added energy of 10,000,000,000 kilowatt-hours represents a fuel saving in excess of 15,000,000 barrels of fuel oil per year. An assured market is available for the full potentialities of the lower basin portion of the stream as long as such projects are so planned and so financed that the costs at the market are competitive with steam with due regard to the reliability of delivery and continuity of service.

Before a selection of projects can be made it will be necessary that the seven Colorado River basin states agree upon their respective rights to deplete the water supply of the Colorado River or that the courts apportion available water among them. Each state also will need to select from the potential projects within its boundaries those it desires to have constructed to consume its allocation of water. The many decisions and selections to be made require a vast background of factual information.

Although the figure for total cost cannot mean much at the present time because all the contemplated projects cannot be built, as some of the irrigation projects lack sufficient water, and some of the projects lack sufficient market; nevertheless it is interesting to know that the figure for the construction cost of the total 134 projects is $3,460,497,200. When they are being planned, each project or related group of projects should be analyzed separately for authorization to determine the relation of economic benefits to cost.

POWER PROJECTS FOR SERVING THE LOWER BASIN

The river profile shown in Figure 2 includes those power projects that might be used to supply the Pacific Southwest power market and Table I summarizes the statistics about them.

The uppermost project shown is Glen Canyon. In the "Comprehensive Report" this project is considered as having a reservoir with a storage capacity of 8,600,000 acre-feet. At 182 miles upstream at Dark Canyon, there is contemplated a project with a reservoir having a capacity of 1,400,000 acre-feet. The capacities of the two plants would be 400,000 and 350,000 kw, respectively.

The Department of Water and Power has been making studies of which some contemplated the use of a reservoir at Glen Canyon of 25,000,000 acre-feet at elevation 3,688 feet. The "Bureau of Reclamation Report" mentions the possibility of a reservoir as large as 34,000,000 acre-feet. The fundamental purpose of a large reservoir is to get increased energy output at Glen Canyon as a result of the greater storage and higher head without having to transmit over the prohibitive distances from Dark Canyon. The large reservoir also has tremendous advantage in prolonging the lives of all the downstream plants by retention of silt. A tentative estimate of plant capacity at Glen Canyon with the large reservoir is 655,000 kw.

Considerable exploratory drilling work has yet to be done before a final site selection for the dam can be made. The Department of Water and Power has made available to the Federal Government $60,000 to carry on such explorations.

The Hoover Dam project plant has an installation of 1,030,000 kw. The contracted firm energy during the contract life of the project will average 4,115,000,000 kilowatt-hours per year. The purposes served by the project are flood control, river regulation, irrigation for Imperial and Coachella Valleys and other lower river projects, domestic water for the Metropolitan Water District, recreation, power and limited intergration with other plants on the river, and integration with the plants of the operating agents. The project is self-liquidating, largely through the sale of power, and returns three per cent interest on the government investment.

The Parker project of 120,000 kw makes deliveries presently to Arizona and Imperial Irrigation District. The Metropolitan Water District ultimately becomes the owner of one-half of the plant and will use the energy for pumping water in its aqueduct.

The Davis project of 225,000 kw, which is now under construction, will have a reservoir which will be used to reregulate for irrigation requirements.

The largest of the potential projects is that known as the Marble Canyon–Kanab Creek Project. A 300-foot dam constructed at the Marble Canyon site would divert part of the water from Grand Canyon and deliver it through a tunnel to a generating plant of 1,250,000-kw capacity.

Bridge Canyon Dam is to be located approximately 115 miles upstream from Hoover Dam. The available head is approximately 670 feet. Without upstream storage, the firm capacity will be reduced to about half the output shown in Table I unless the present rights of the power contractors at Hoover Dam to integrate with their own systems are sacrificed to river co-ordination, with Bridge Canyon taking all credit for increase in energy output of the combined plants.

The average amount of silt reaching Lake Mead is stated to be 137,000 acre-feet per year. The amount reaching the Bridge Canyon site is only slightly less than this. From this it becomes evident that unless other upstream and tributary stream storage is provided, Bridge Canyon would be silted up in slightly over 25 years. The Bridge Canyon project, exclusive of any irrigation features, is estimated to cost $234,400,000.

Bridge Canyon has been incorporated with the Central Arizona project in a recent bill submitted to the United States Senate and on which hearings were held recently.

In view of the fact that there is not enough water available to permit construction of all of the potential projects, the regional directors, in presenting their report, make the following recommendations:

1. That the states of the Colorado River basin, acting separately or jointly, recommend for construction, as the next stage of development, a group of projects, the stream-flow depletions of which assuredly will fall within ultimate allocations of Colorado River water which may be made to the individual states.

2. That the states of the Colorado River basin determine their respective rights to deplete the flow of the Colorado River consistent with the Colorado River Compact.

3. That additional investigations and appropriations to the Department of the Interior for use by the various agencies within that department for these investigations, be approved.

Determination of Initial Development. With respect to any of the future developments for power along the Colorado River, the Bridge Canyon project is the nearest to the Pacific Southwest market and obviously has prime consideration as the nearest project to be developed. Presumably, the output figure is dependent on certain other developments being made upstream and does not represent the capability of the project as contemplated in any initial program involving the construction of the Bridge Canyon project only.

A study made by the Federal Power Commission under the direction of E. W. Cramer, dated January 1, 1942, indicated that with upstream depletion of 2,671,000 acre-feet, which is somewhat less than the current depletion, the firm energy output at Bridge Canyon would be 1,840,000,000 kilowatt-hours. Since the Bridge Canyon active storage is only 2,650,000 acre-feet, which will be reduced rapidly by silt encroachment, the firm power capacity will be very sensitive to depletions by the upper basin, and since the depletions will be initially somewhat larger than contemplated in the Federal Power Commission study, the firm energy at Bridge may be even lower than the 1,840,000,000 kilowatt-hours. To some extent the Bridge Canyon project tends to approach the characteristics of a run-of-stream plant.

Figure 3 shows the air-line transmission distances involved in the projects under consideration. If the firm energy from Bridge Canyon as an initial project should prove to be approximately one-half of that indicated in the report, as indicated by the Federal Power Commission's figures, then with transmission-line distances to the Southern California market from Bridge Canyon being in excess of 335 miles, it would not be economically

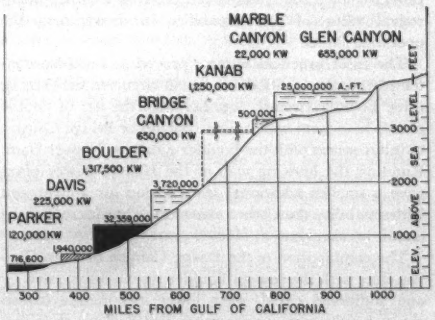

Figure 2. River profile of reservoirs and hydroelectric power plants

attractive to transmit energy where a large percentage of the energy would be essentially only fuel-saving, or secondary energy, instead of firm energy. With this possibility in mind, it seems desirable to the Department of Water and Power to investigate the nature of developments along the Colorado River that should be made initially in order to choose the most economical combination. The three choices that are involved are as follows:

1. Bridge Canyon reservoir and power plant only.

2. Glen Canyon reservoir and power plant only.

3. Bridge Canyon reservoir and power plant plus Glen Canyon reservoir.

Of these three possibilities, the first project requires the least transmission cost but produces a relatively small amount of firm energy. The second project has the greatest transmission cost but develops a relatively large amount of firm energy. The third project involves a large amount of power plant and reservoir investment, but requires a relatively low transmission line investment and develops a relatively large amount of firm energy.

As Glen Canyon power plant is approximately 470 miles from the Southern California market, it does not seem economically feasible to give consideration to any initial program for power developments supplying that market from further upstream than Glen Canyon.

Transmission Considerations. A study of the physical feasibility of such transmission to Los Angeles was made on the network analyzer of the Bonneville Power Administration. Solely for the purpose of calculations, the studies were made on the basis of transmitting the normal peak capacity of the Boulder system of the department, together with 300,000 kw from either Glen Canyon or Bridge Canyon, by using certain transmission line additions in combination with the city's present Boulder–Los Angeles transmission system. Such studies provided for a reduction of ten per cent from the theoretical value of line capability in determining the operating limits.

The most practical systems proved to be those contemplating the addition of a fourth circuit to the existing three Boulder circuits, together with the use of double circuit lines from either Glen Canyon or Bridge Canyon to interconnect with the Boulder system at Hoover Dam. Running the lines by way of the Hoover power plant gave a smaller additional transmission investment and better stability than other alternatives but increased the circuit breaker duty at Hoover power plant.

The combination of the Bridge Canyon or Glen Canyon lines with the present Boulder system augmented by one additional circuit gave lower incremental investments for the same performance and delivery than was obtainable by consideration of separate systems. In all cases the physical feasibility of transmission of these amounts of power was demonstrated.

In these studies, no effort was made to determine precisely either the minimum compensation or the economical compensation that would be desirable for the lines involved. The tests only went sufficiently far to determine that the transmission performance was such as to be considered physically practicable and economically feasible.

It was found that operation of the lines at 287,500 volts was of lower cost and gave better over-all economy than would be obtained by the use of higher voltage lines to produce the same capability.

This study, however, would not take into account the characteristics and use of other upper basin reservoirs, which would affect the problem to some extent. The use of Glen Canyon reservoir served to reregulate the depleted flow so that no special demand had to be made on the upper basin to meet the required 10-year average of $7\frac{1}{2}$ million acre-feet in accordance with the compact. If such a reservoir were not in operation there would be, under ultimate conditions of upper basin use, eight years in a period of ten years when such use of water would have to be reduced to make delivery to the lower basin under the 10-year average requirement of the compact.

In determining the costs for power produced by these individual projects, or in combination, it is necessary to face the formidable problem of allocation of investment

Table I. Power Plant Capabilities of the Lower Colorado River Developments

Power Plant	Installed Capacity, Kw	Average Annual Output, Million Kw-Hr		Capacity, Acre-Ft
		Firm Energy	Secondary Energy	
Glen Canyon	400,000	2,200	533*	8,600,000
				3,000,000
Marble Canyon	22,000	164	32*	500,000
Kanab	1,250,000	6,570	2,360	
Bridge Canyon	650,000	3,440	395	3,720,000
Boulder†	1,317,500‡	4,115	800	32,359,000
Davis**	225,000	750	145	1,940,000
Parker*	120,000	500	100*	716,000
Totals	3,992,500	17,666	4,365	

* Estimated values.

† Constructed to partial capacity.

‡ Ultimate capacity.

** Under construction.

ǂ Constructed.

costs to multiple purposes. At this initial stage of consideration, it was neither desirable nor possible for the department to make any comprehensive determination of such allocations. Nevertheless, some tentative allocation is necessary at this time so that the results will not be out of line with those ultimately to be determined.

In this study, no diversion to Arizona was considered at or above Bridge Canyon so all of the investment and expenses of Bridge Canyon development were considered for power purposes.

It was considered that certain parts of the investment at Glen Canyon would be charged to lower river projects profiting thereby, excepting the Hoover project, which, like Glen Canyon, renders service to other projects. In this problem, for simplicity and conservative results, such allocation of Glen Canyon investment was made only to the Bridge Canyon project, although in the future some further allocations might be considered. The allocations assumed for Glen Canyon Dam were as follows:

Flood control ..... 11.5 per cent
Reregulation for compact ..... 39.9 per cent

Reregulation for Mexican Treaty	4.4 per cent
Power production at Bridge Canyon	22.7 per cent
Power production at Glen Canyon	21.5 per cent

The figures are highly tentative and in no way reflect what may be the final judgment on an appropriate allocation.

In making the cost study it was found desirable to confine the figures to that portion of the power which possibly might be used in the Los Angeles system, rather than trying to make an estimate for the total output. For this tentative study, it was decided to assign 40 per cent of the capacity, energy, and costs of the power investments at Bridge Canyon and Glen Canyon to the Los Angeles system and deliver corresponding amounts of energy over the transmission system heretofore described. These quantities are lower than the transmission capabilities determined on the network analyzer, that is, 300,000 kw, and are therefore conservative from the viewpoint of costs.

Table II. California Priorities

Order of Priority	Project	Capacity Acre-Ft
1.	Palo Verde for 104,500 acres of land;	
2.	Federal Yuma project for 25,000 acres	3,850,000
3.	Imperial and Palo Verde	
4.	Metropolitan Water District	550,000
5.	*A*—Metropolitan Water District	550,000
	B—San Diego	112,000
6.	Imperial and Palo Verde	300,000
Total		5,362,000

In determining the annual costs for deliveries of power to the City of Los Angeles, the investment in dams and reservoirs allocable to power and the investment for generation was amortized at two per cent over a period of 50 years.

In view of rapidly changing costs and varying possibilities of allocations of investment, it would be premature to report, as a matter of record, actual costs per kilowatt-hour. However, the relative unit costs per kilowatt-hour are indicated in Figure 4. It is sufficient to state that the costs obtained in our preliminary and tentative estimate for Bridge Canyon alone for firm energy is considerably in excess of steam plant unit costs in Los Angeles and would not be attractive. In comparison with this cost, the cost of energy for the project developed at Glen Canyon alone appears to be approximately 70 per cent of such cost, and the cost for the Bridge Canyon development augmented by Glen Canyon storage would be only 60 per cent of the cost of the single development at Bridge Canyon. These results indicate that the costs of the Bridge Canyon development augmented by Glen Canyon storage are sufficiently lower than steam plant costs to make the use of such energy desirable.

There is not sufficient margin in these costs to permit the revenues from power to carry the burden of subsidizing any irrigation projects that might be proposed to be developed concurrently with the power projects which just have been under discussion.

On the basis of the foregoing results, the City of Los Angeles has suggested that the Bureau of Reclamation make a study to determine the initial type of project that should be authorized by the Congress. This will involve such comparisons as have been presented in this discussion.

A further objective of their study would be to determine the economic reservoir capacity to be provided at or near Glen Canyon, taking into account the modifications occurring because of other upper basin storage and the characteristics of flow as a result of their operations. The silt problem probably will point the way to the desirability of relatively large storage at Glen Canyon.

CENTRAL ARIZONA PROJECT

For a period of three years the Bureau of Reclamation has been carrying on investigations of the Central Arizona Project, which have been conducted under an agreement with the state of Arizona.

In this work consideration was given to three alternative projects:

1. The Marble Canyon route, wherein water would be diverted from the proposed Marble Canyon reservoir, through 143 miles of continuous tunnel to discharge into the Verde River, and finally be delivered at Granite Reef Dam on the Salt River.

2. The Bridge Canyon route, wherein water would be diverted from the Bridge Canyon reservoir, through a 78.5-mile continuous tunnel to the Big Sandy River, and thence by 235 miles of aqueduct and 11 short tunnels totaling 13.7 miles to the Granite Reef Dam.

3. The Parker route, wherein water would be pumped from Havasu Lake at Parker Dam, through four lifts totaling 985 feet, and thence flowing by gravity through 235 miles of aqueduct to Granite Reef Dam. The diversions contemplated were uncertain but ranged from one to two million acre-feet.

Provisions of Bill. In April 1947, Senator McFarland of Arizona introduced a bill in the United States Senate (*S.1175*) authorizing the construction, operation, and maintenance of a dam and incidental works in the main stream of the Colorado River at Bridge Canyon, together with certain appurtenant dams and canals for other purposes. Under the detailed provisions of this bill the Secretary of the Interior is authorized to construct, operate, and maintain:

1. A dam and incidental works at Bridge Canyon.

2. A tunnel and main canal from Bridge Canyon to Granite Reef Dam together with necessary distribution canals.

3. Power plant and transmission lines for the fullest development of electric energy from the works.

4. Numerous dams and incidental works, above Bridge Canyon and on various tributaries of the Gila River in Arizona and New Mexico for the successful operation of the project.

Provision was made, however, that construction of the tunnel and portion of the canal shall be deferred until Congress appropriation indicates that it has determined that economic conditions justify its construction. To provide means of diversion of water from the Colorado River to the main canal pending the construction of the tunnel and portion of the canal and for use thereafter as supplemental and stand-by works, the Secretary of Interior is authorized to construct, maintain, and operate from appropriations authorized by the act an aqueduct from Lake Havasu to and connecting with the main canal in the vicinity of Cunningham wash and pumping plants to raise the water from Lake Havasu to such elevation as may be required to provide gravity flow of the water from Lake Havasu to the main canal.

V. E. Larson, assistant regional planning engineer for Region III of the Bureau of Reclamation, in a testimony stated:

> The stage has now been reached where almost one-half of the total water applied in the area is pumped. During the period, 1940–1944, this excess withdrawal averaged about 468,000 acre-feet a year. As a result ground water levels are dropping progressively.

Comment should be made to the effect that despite this shortage and profligate use of underground water, Arizona has not passed any regulations regarding use of underground waters and has permitted the exploitation of such water during a period of high crop prices, where those who embarked on this venture of mining water, were doing so with the full knowledge that it was short-lived but presumably well worth the cost. Whether such farms have to be "rescued" is the problem.

Larson continued,

> On June 18, 1946, Senator McFarland introduced for consideration by the United States Senate, Bill *2346* (later superseded by *S. 1175*), for the purpose of authorizing construction of the Central Arizona project on the basis of the Bridge Canyon route. Significant among its provisions were modifications of the existing Reclamation Law to extend the repayment period for costs allocated to irrigation from 40 to 80 years, and to reduce the interest rate for costs allocated to power from 3 to 2 per cent.
>
> The Bureau report affirmed previous contentions that the Central Arizona project is essential to sustain the existing economy in the area and that it is feasible from a construction standpoint. However, operation of the project would not provide sufficient revenue from power and irrigation to repay the construction costs allocated to the benefits in accordance with present Reclamation Law. Full repayment within the fixed time limits would require a power rate such as would preclude the sale of electric energy.

The report covered both the Bridge Canyon and Parker routes and indicated that:

> Either route could be constructed under modern engineering and construction methods, and that the preponderance of advantage lies with the Parker route, because of its lower total cost, shorter construction time, and greater economic feasibility.

Costs, Revenues, and Returns. In round numbers the cost of the entire Central Valley project as described in the present Senate bill *S.1175*, including the aqueduct from Bridge Canyon, is $1,011,500,000. It does not seem reasonable that such ever would be built, so consideration will be given only to the figures quoted for the Parker route project. The total cost of this project is nearly $605,000,000 made up as follows:

Bluff Dam and reservoir	$ 25,700,000
Coconino Dam and reservoir	$ 6,400,000
Bridge Canyon Dam and reservoir	$164,200,000
Bridge Canyon power plant	$ 60,800,000
Havasu pumping plants	$ 20,500,000
Granite Reef aqueduct	$107,400,000
Central Arizona Works	$133,600,000
Power transmission system	$ 86,100,000
Total	$604,700,000

The annual cost for operation and maintenance was $5,130,000 with $1,985,000 for replacements.

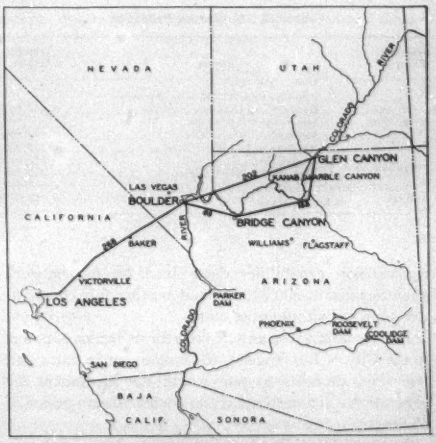

Figure 3. Air-line transmission distances involved in projects under consideration for Los Angeles

A charge to the farmer of $4.50 per acre-foot at the farm headgate is estimated. On the basis of delivery figures given in the statement, it appears that about $3,400,000 per year would be derived from this source. During the first 50-year period, the returns from power on the basis of 4 mills per kilowatt-hour at the market would average about $11,400,000 to produce a total revenue of $14,800,000 annually. Over an 80-year period the annual revenue is estimated to average $14,070,000.

The manner in which these returns are applied to the costs of the project is described in Larson's testimony as follows:

> In all studies, the interest component of the payments made on the power investment is considered as being applicable in aiding the retirement of the irrigation obligation during the power repayment

period. In addition, under provisions of Senate bill 433, where eretirment of the irrigation investment within an 80-year period is provided for, all net power revenues accruing after the power investment is repaid are applied to the repayment of the irrigation obligation until full repayment of the irrigation construction costs is accomplished.

The estimated average annual costs repayable from project operations, based on April 1946 price levels, would be $13,952,000 under the terms of Senate bill 433. Net average annual returns would be $14,070,000. This results in a return-to-cost ratio of 1.01 to 1. A power rate of $0.00396 per kilowatt-hour would provide a return-to-cost ratio of 1 to 1.

Under the terms of existing Reclamation Law the estimated average annual costs would be $19,059,400. Net average annual returns would be $14,810,300. The return-to-cost ratio would be 0.78 to 1. In order to effect a return-to-cost ratio of 1 to 1 under the terms of existing Reclamation Law it would be necessary to sell the power at a rate of $0.0055 per kilowatt-hour.

In commenting on the features that just have been discussed, Raymond Matthew, chief engineer for the Colorado River Board of California, re-emphasized that the project does not pay out under the Reclamation Law, and that it is only under the condition that the nonreimbursable items are increased and the repayment for the irrigation items extended from 40 to 80 years, and the power revenues for the entire period used, that the returns are about equal to the estimated annual costs.

On the basis that the interest component on power investment is not applicable to repayment of the capital costs of irrigation, and that such interest component is a necessary part of project costs in addition to repayment of all reimbursable capital costs, operation and maintenance expenses and replacement, Matthew stated:

In order to provide sufficient revenue to secure repayment in 50 years, one of three alternatives would be required:

1. With irrigation water revenue based on $4.50 per acre-foot at farm headgate, the commercial power rate would have to be increased to 7.13 mills per kilowatt-hour at load centers.

2. With commercial power revenues based on 4 mills per kilowatt-hour at load centers, the charge for irrigation water at farm headgate would have to be increased to $18.56 per acre-foot.

3. With commercial power revenues based on 4 mills per kilowatt-hour at load centers and irrigation water revenues based on $4.50 per acre-foot at farm headgate as assumed in the Bureau's report, a capital subsidy from the United States Treasury of $447,545,000 would be required.

Matthew had pointed out that "the cost of operation and maintenance and replacements chargeable to irrigation exceeds the irrigation revenue." In his presentation he indicated that, if, in addition, irrigation was charged with the total cost of its power as an operating expense, the annual charges would be $9.55 per acre-foot for which the farmers would be paying only $4.50.

POWER OPERATIONS

With respect to certain phases of the power development, Larson stated:

Reservoir operation studies for power production have been made by the Bureau of Reclamation on the basis of full co-ordination and integration of the Government plants on the lower Colorado River. It has been assumed that Davis power plant would be completed and that the full designed capacity would be installed in Hoover power plant at the time that Bridge Canyon power plant was completed. In all studies, the amount of water available for power generation has been incidental to river regulation, flood control, and irrigation releases and storage.

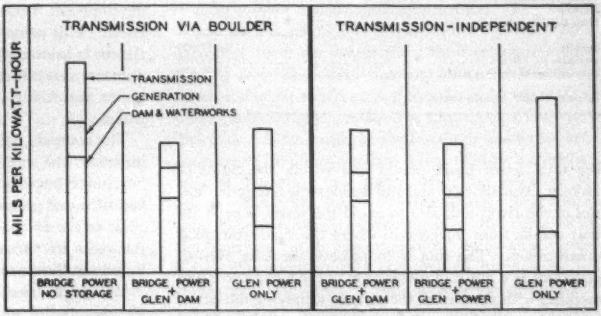

Figure 4. Power costs involved in projects under consideration in the lower basin

Co-ordinated operation of all power plants produces the largest possible amount of firm power. Under this system, the plants with small reservoirs would generate a greater percentage of the total power produced during periods of high runoff than they would in low runoff periods. Concurrently, the other plants with large reservoir capacity could reduce their output and store all possible water for use in low runoff periods. With this system of operation it is possible to produce a higher total system firm energy than under independent operation.

The period 1931 to 1940, inclusive, is taken as a period of low flow of the river and is assumed as the critical period for the reservoir operation studies. These studies were computed for three conditions of development of the Central Arizona project:

1. Initial conditions, assumed to be those resulting at the completion of the construction of the project.

2. Ultimate development, assumed to be 50 years after initial conditions.

3. Average conditions, assumed midway between initial and ultimate development.

The potential output of the Colorado River plants under the co-

ordinated operation . . . is 10,725,000,000 kilowatt-hours of firm energy annually. Of this amount Bridge Canyon is credited with 4,675,000,000 kilowatt-hours, Hoover with 4,500,000,000 kilowatt-hours, and Davis and Parker with a combined total of 1,550,000,000 kilowatt-hours.

The diversion of energy for irrigation pumping ranges from 1,154,000,000 kilowatt-hours in the early years to 1,633,000,000 kilowatt-hours in the latter years. The net average generation available from the energy credited to Bridge for sale to the potential market is 3,070,000,000 kilowatt-hours.

The comprehensive development including Glenn Canyon affords an excellent opportunity to integrate the total lower basin plants well within the rights of Hoover Dam allottees and still develop the full potentialities of the river, and also to avoid the waste of capacity that results from integration where the main storage is downstream. The aim is to achieve the best over-all economy as a result of integration of the Colorado River facilities with those of all the systems supplying the entire market area including Arizona, Nevada, and Southern California.

Table III. Arizona's Position (Carson)

All figures are in acre-feet

Firm water available to lower basin[III(a) and III(b)]		8,500,000
California's limitation	4,400,000	
Nevada	300,000	
Utah and New Mexico	131,000	
Subtotal		4,831,000
Available for Arizona		3,669,000
Arizona's use of the Gila River		1,000,000
Arizona's "right" in main stream		2,669,000

CONFLICTING CLAIMS OF ARIZONA AND CALIFORNIA FOR WATER RIGHTS

By far the most important problem, in connection with the development of the river, that is pressing for solution is that of adjudicating the conflicting claims of Arizona and California as they have arisen out of their separate interpretations of the Colorado River Compact, the California Limitation Act, the Boulder Canyon Project Act, and the several contracts between the respective states and the United States Government. This article will try to give sufficient background of the facts, discussion, and contentions to bring about an understanding of the issues and the basis for the respective claims.

In his statement before the Senate Committee, Larson says,

> In the absence of a compact dividing among the various states involved, the water apportioned to the lower basin by the Colorado River Compact, the determination of Colorado River water available for diversion to the Central Arizona project, herein presented, is based upon interpretations by responsible officials of the state of Arizona. It is recognized that these interpretations are not the same as those of some other states in the Colorado River basin.

As a historical background it should be stated that, by 1922, the irrigation developments in Imperial Valley, which had begun to an important extent more than 20 years previously, had grown to the point where, in years of low runoff, they were using the entire flow of the Colorado River in the months of minimum flow. The prior right, so established by beneficial consumptive use, definitely limited the use of the stream by upper basin states, whose irrigation developments were lagging with respect to those in the lower basin. With projects such as the Boulder Dam being advocated, which might limit still further the states in the upper basin, and with the stream being an interstate, international, and navigable stream, the United States Government had jurisdiction, and the only feasible way to protect the upper basin and thus clear the way for further lower basin development was for an interstate compact to be formulated. This compact was signed in November 1922 by the commission and promptly ratified by all states except Arizona who ratified in 1944. The compact defines the upper and lower basins and makes allocations to each basin.

The compact defines the upper and lower basins and in article III paragraph (*a*) allocates to each basin the "exclusive beneficial consumptive use of 7,500,000 acre-feet of water per annum."

In article III paragraph (*b*) the lower basin is given the right to "increase its beneficial consumptive use" by one million acre-feet per annum.

Paragraph (*c*) of article III deals with obligations of the two basins under certain circumstances to supply water to meet the requirements of any future treaty with Mexico.

Article III paragraph (*d*) states,

> The states of the upper division will not cause the flow of the river at Lee Ferry to be depleted below an aggregate of 75,000,000 acre-feet for any period of ten consecutive years.

In making this provision, the commission was cognizant of the erratic flow of the river and was endeavoring to avoid having a condition develop where no water would reach the lower basin from the upper basin for occasional years during a dry cycle. The intent is that the minimum releases under such a program of delivery, added to water sources within the lower basin, will enable the lower basin to obtain its allotment.

Article VIII indicates that perfected rights to the beneficial use of water of the Colorado River are not impaired by the compact, and that the claims of the lower basin appropriators are to be satisfied from stored water.

The Boulder Canyon Project Act authorized the Secretary of the Interior to construct, operate, and maintain a storage dam, power plant, and incidental works at

Black Canyon or Boulder Canyon and the All-American Canal. Such construction was not authorized to be started until suitable contracts had been executed for sale of water and power, which would assure repaying the cost of the project with interest at four per cent together with covering maintenance, operation and replacements, and repayment of the canal investment, without interest under the provisions of the Reclamation Law. As the users of the All-American Canal were receiving stored water in satisfaction of their rights by prior appropriation, provision was made that there should be no charge for use, storage, or delivery of such water in the Imperial Valley and Coachella Valley.

The act also authorized a Tri-State Compact between Arizona, California, and Nevada, which never was consummated, but is of interest in that it indicates that for all provisions of use beyond Article III paragraph (*a*), Arizona and California are on a par.

California passed the Limitation Act in essentially the exact words quoted from the Project Act.

During 1930, contracts for the delivery of water to various contractors under the Project Act were consummated. Before such were made, however, the secretary demanded an agreement between the California water interests to set up priorities of rights. This agreement resulted in the priorities shown in Table II.

In its essentials, Arizona's position is expressed by its special attorney, Charles A. Carson (Table III).

In general Larson agreed with Carson. He indicated also that, based on long term averages, there is available 220,000 acre-feet more than allotted by the compact, and that Arizona is entitled to one quarter of that, four states being involved. However, James H. Howard, general counsel for the Metropolitan Water District for Southern California, in his testimony pointed out three erroneous assumptions in the Arizona interpretations:

1. That, by the terms of the California Water Limitation Act, California agencies are excluded from participation in the use of water referred to in Article III, paragraph (*b*), of the Colorado River Compact.

2. That the measure of beneficial consumptive use of waters of the Gila River in Arizona is the amount of depletion of the virgin flow of the river at its confluence with the Colorado River, and not actual "beneficial consumptive use."

3. That the 4,400,000 acre-feet of water apportioned by Article III, paragraph (*a*) of the Colorado River Compact, to which California is limited by the Project Act and the Limitation Act, is subject to further reduction by reason of evaporation and other reservoir losses, particularly at Lake Mead.

Howard's testimony substantiated California's claim that the one million acre-feet granted to the lower basin under the compact article III paragraph (*b*) is water that is to be shared alike by Arizona and California. He also showed why Arizona's consumptive use should be measured in terms of actual diversion less return flow, which is a value approximately one million acre-feet more than now claimed by Arizona. His discussions showed how the wording of the contracts and substitution of stored water for prior rights on the stream were incompatible with California's assuming storage losses.

Recalling the California priorities for water given in Table II and the long period of below average flows, it becomes apparent that the 1,200,000 acre-feet proposed to be taken out of the main stream for the benefit of the Central Arizona project would leave only about 300,000 acre-feet available to the Metropolitan Water District under its highest priority right and thus cut into even the 4,400,000 acre-feet of water available under article III, paragraph (*a*), of the Colorado River Compact. This is only one quarter of the total water, for which the district will have invested $274,000,000 to bring to the coastal cities of Southern California.

Those officials responsible for California's water supply for irrigation and for domestic purposes no longer can run the risk of having such water supply jeopardized by such acts of Congress as that which has been discussed. If the Colorado River is measured in terms of the needs of the Southwest, it is not adequate. If it is measured by those needs that communities are willing to pay for in order to be supplied it will be adequate. By "willing to pay for" is meant the development of projects on a basis that meets the standards of the Reclamation Law as used with its original interpretation. With this in mind, and with confidence that contracts with the government would not be jeopardized by future acts of Congress, $2\frac{1}{2}$ or 3 million people in the Southern California area constructed the Metropolitan Water District aqueduct to give insurance that water would be available for possibly 8,000,000 people to reside there. The cost of that project is almost exactly equal to the value of all the farm and ranch properties in the entire state of Arizona. To augment that economy in Arizona by not more than one-third, a project is being proposed of which even the irrigation features alone exceed the total farm values in the entire state. For this the Government will get back part of its money in 80 years and lose interest on all of it. California believes that such unfeasible irrigation projects will jeopardize its ultimate water supply, thus wasting its investment in the Metropolitan Water District aqueduct. A bill has been introduced into Congress to permit settlement through adjudication by the United States Supreme Court.

The Colorado River power projects are essential to the growth of Southern California but must be developed conservatively along lines of the original Boulder project to attract congressional support. These proposed projects at still greater distances cannot carry an undue amount of unfeasible irrigation. Neither can such power projects stand economically the diversion of water among them. The Bridge Canyon project by itself, and without undue support by the Hoover Dam project, would be an unfeasible power project, but when operated in conjunction with adequate upstream storage such as that afforded by Glen Canyon, and augmented by the future power developments which such storage makes possible, the entire Colorado River development can be a successful and useful project.

New Overcurrent Tripping Device

H. L. RAWLINS
MEMBER AIEE

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MEMBER AIEE

The limitations of present overcurrent tripping devices for low-voltage systems have hastened the development of a single unit which can be adjusted to any desired characteristics and meets all the requirements for delayed tripping devices.

THE tripping requirements for low-voltage circuit breakers have been satisfied until recently by a self-contained series device that provided sufficient delay on overcurrent tripping for the immediate load at hand and which became instantaneous at rather low values of fault current. This characteristic was sufficient to provide for some circuit breaker selectivity on the lower values of fault current. With increased concentrations of power, the necessity for selective tripping of low-voltage circuit breakers throughout a greater range of fault currents has become apparent. It is recognized that relays and accompanying current transformers are undesirable in most installations from the standpoint of complexity and cost.

The selective tripping of these circuit breakers has been accomplished in some instances by the addition of definite-short-time delay tripping devices that are effective throughout the required range of fault currents although an improved type of delayed trip is needed to simplify the application of low-voltage circuit breakers.

REVIEW OF DELAY ELEMENTS USED ON OVERCURRENT TRIPS

The reliability and usefulness of a delayed overcurrent trip depends mainly upon the characteristics of the delay element. The delay elements in general use at the present time are

1. *Liquid Film Delay.* In this device, the delay is obtained by the adhesion of liquid to two co-operating surfaces. This has been by far the most popular type of delay device as it is relatively simple in construction, the only requirement being two carefully finished surfaces. It has, however, certain limitations: inaccurate timing, inability to operate with suitable delay on high values of fault current, and failure to provide any delay whatsoever when grit or dirt gets between the co-operating surfaces. Also the liquid is exposed to the atmosphere where it may become dirty, sludged by oxidation, or gummed by evaporation.

2. *Thermal Delay.* The thermal trip device is simple on the smaller circuit breakers of relatively low interrupting ability because the heating element may be connected directly in the circuit without fear of damage. For use on higher interrupting ability circuit breakers, the heating elements usually are connected in the circuit by transformer action which, because of saturation, protects the heating elements on high values of fault current. It is necessary to compensate for varying ambient temperatures either with a second bimetal element or to provide a magnetic source of energy for tripping the circuit breaker which is released by bimetal movement but which is inoperative below fixed current values, the latter being preferred. The limitations of the thermal trip device are: it cannot be used to provide delay at high values of fault current, it is relatively complicated when used on higher rated circuit breakers, and it is not suitable for use on higher rated d-c circuit breakers.

3. *Dashpot Delay.* Dashpot delay involves the actual displacement of liquid by a piston in a cylinder and, although not in general use at present for low-voltage circuit breaker tripping devices, it is used for obtaining delayed tripping with transformer trip devices on higher voltage circuit breakers. The defects of the conventional dashpot arrangement are: dirt or foreign material may enter the liquid and cause sticking of the piston, and the piston may stick because of sludging or gumming of the dashpot oil. A tripping device involving a moving core in a completely sealed dashpot and a differential flux arrangement operative to trip the circuit breaker after a predetermined travel of the core is used on certain types of small moulded-case circuit breakers but is not suitable for obtaining delays at even moderate values of overcurrent due to instantaneous action of the external armature.

4. *Mechanical Delay.* Mechanical delays involving escapement mechanisms, air vanes, or inertia devices connected through gearing to series magnets have been in common use in foreign countries but have not been used in the United States until recently. In the quantities involved in low-voltage circuit breaker manufacture, these devices are not suitable for American manufacturing. Their maintenance also requires an unusual degree of skill which is not generally available.

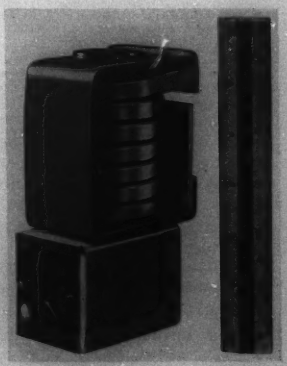

Figure 1. New trip unit of 225-ampere rating

Essential substance of paper 47-145, "An Improved Overcurrent Tripping Device for Low-Voltage Circuit Breakers," presented at the AIEE summer general meeting, Montreal, Quebec, Canada, June 9-13, 1947, and scheduled for publication in the AIEE *TRANSACTIONS*, volume 66, 1947.

H. L. Rawlins is manager of the protective devices engineering department and Jerome Sandin is an electrical engineer with the Westinghouse Electric Corporation, East Pittsburgh, Pa.

REQUIREMENTS FOR DELAYED TRIPPING DEVICES

The problems involved are not those of application, but concern the design of the devices for obtaining delay. The requirements for satisfactory tripping devices are few, but all should be fulfilled by a single device.

1. Sufficient delay must be provided throughout the range of motor starting currents to permit starting of motors having the highest values of locked rotor currents.
2. Above locked rotor currents, the device should be capable of providing the shortest permissible delay necessary for selectivity.
3. In order to provide the maximum possible protection to associated equipment and to other circuit breakers when connected in cascade, the device should be capable of tripping instantaneously at any fault current up to the short time rating of the circuit breaker.
4. There should be a wide range of pickup adjustment on the delay element.
5. The device should be suitable for both a-c and d-c circuit breakers.
6. The trip unit should be easily removable and interchangeable to facilitate changes in circuit breaker ratings and characteristics.
7. The device should be reliable and maintain its reliability without maintenance under all types of service conditions.

An analysis of the existing elements, together with the requirements for over-current tripping devices, indicated that the ideal timing device should

1. Provide delay by the positive displacement of a fluid.
2. Be hermetically sealed.

THE NEW OVERCURRENT TRIPPING DEVICE

An entirely new type of device incorporating all of the required features is shown in Figure 1. The unit shown has a 225-ampere coil rating and is suitable for both 225- and 600-ampere frame size circuit breakers.

Figure 2 shows the elements of this trip unit.

Pickup occurs when the attraction of the cores exceeds the restraining force exerted by the weight of the sealed unit and the calibration spring. Delay is obtained by positive displacement of the fluid which is forced through the space between the upper core and the timing stem. The timing stem is the only variable in the sealed unit, and its diameter determines the size of annular orifice and, therefore, the time characteristics.

In operation, the upper core is held stationary by the attraction of its upper surface to the annular edge of the magnetic frame while the attraction between the upper core and the lower core raises all parts of the sealed unit except the upper core. This action raises the trip bar to unlatch the breaker. Successful operation requires that the force of attraction of the upper core to the magnetic frame exceed all forces restraining the movement of the sealed unit, these are, the trip load required to unlatch the circuit breaker, the weight of the moving elements, the pull of the calibration spring in its maximum position, and the inertia forces of the moving masses. Strong upward pull on the upper core is obtained by increasing the flux density on the top surface of the core through suitable shaping of magnetic parts, the use of a small air gap, and the use of tapered conical surfaces between the upper and lower cores. The calibration or setting for minimum pickup is obtained by applying a suitable restraining force on the moving element. The toggle arrangement used to apply spring load to the moving element permits wide variations in pickup settings.

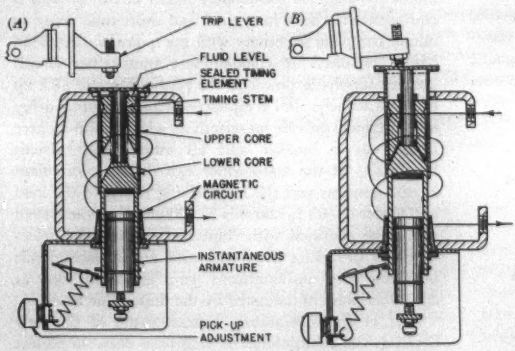

Figure 2. Sectional view of new unit

A—Normal position
B—Position when tripping with time delay
C—Position when tripped by instantaneous armature

The instantaneous armature provides for instantaneous tripping of the circuit breaker irrespective of any action within the sealed timing element. On currents above the prescribed value, the instantaneous armature is picked up by the flux inside of the lower core, after it has saturated, and bodily raises the whole sealed element. The value of instantaneous trip current is obtained by adjusting the position or by varying the cross-sectional area of the instantaneous armature. As this armature is within the field of a solenoid, it will have a force exerted on it dependent upon the series current through the coil.

This permits pickup adjustments for the instantaneous armature at all values of current. This would not be the case if it were a clapper type of armature where saturation would limit the forces at higher currents.

Because fluid pressure in the sealed chamber is dependent upon the series current it is possible to provide long time delays for currents up to predetermined values and, by the operation of a by-pass relief valve, to provide short time delay for higher currents. This by-pass valve may be incorporated in the timing stem. The operation of the by-pass valve is simple in that above a certain pressure the valve spring is compressed, permitting the fluid to flow through a much larger orifice than the annular orifice on the outside of the timing stem which provides for long time delay.

The reset spring serves to position the upper core in the normal position and to reset the core after its movement during overcurrent conditions. The storage of heat in the unit gives it a "memory" which may be regulated by making the reset spring weak or strong.

Silicone fluid is used to obtain timing because of its stability at higher temperatures and its smaller changes in viscosity with varying ambient temperatures. A fluid of high viscosity is used as it permits more clearance of moving parts and larger orifices which result in smaller changes in characteristics with manufacturing variations. The tube and top disk are made of nonmagnetic stainless steel because of its high resistivity, sturdiness, and resistance to corrosion. The cores are made of special silicon iron to reduce eddy currents and losses on alternating currents. On sealing, moisture and oxygen are removed from the fluid and internal parts by heat and vacuum treatment which insures freedom from corrosion for the sealed parts. The final sealing of the timing element is performed very effectively by spot welding the disk to the flanged top of the tube. This operation, performed in a fraction of a second, in no way injures the liquid or internal parts.

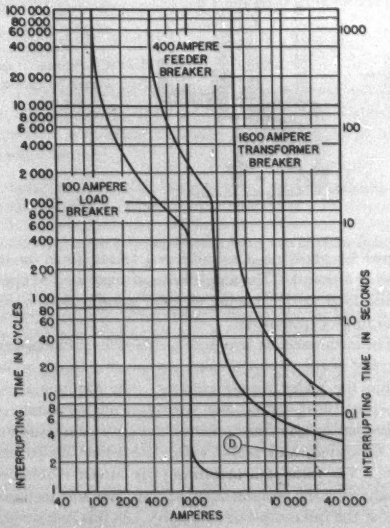

Figure 3. Typical time–current characteristics of circuit breakers equipped with new trip units for selective operation

CHARACTERISTICS

Tests on the new trip unit have revealed that any desired time–current characteristic can be obtained by varying the timing stem. In applying these characteristics to circuit breakers, it is, of course, necessary to maintain certain ratios of ratings to assure selective operation. In the usual application, the ratios are almost always more than sufficient because of other factors. Figure 3 shows the curves for a typical selectivity application.

Here a 100-ampere-load circuit breaker is provided with a long time delay and instantaneous trip to permit motor starting. A 400-ampere feeder circuit breaker is equipped with both long time and short time delay to obtain complete selectivity with the motor starting load circuit breaker. A 1,600-ampere transformer circuit breaker supplying power to the system is set to pick up at 3,000 amperes and is equipped with short time delay only (that will provide for selectivity with the 400-ampere feeder circuit breaker and all other feeder circuit breakers). If the transformer can deliver more than 25,000 amperes and the interrupting rating of the load and feeder circuit breakers is 25,000 amperes, the system should be operated with combined cascade and selectivity by providing the feeder and transformer circuit breakers with instantaneous trip armatures set at 20,000 amperes as indicated by the dotted line at *D*.

One of the outstanding characteristics of the new device is the combination of long time delay to permit motor starting with a wide range of pickup adjustment that permits it to be applied universally for either motor service or for general load service. The short time delay and combined short and long time delay characteristics would be used in selectivity applications and, therefore, would be on back-up circuit breakers only.

TESTS

The design, adaptability, characteristics, and accuracy of pickup and timing of this new overcurrent tripping device have been verified by thousands of tests over a $2^1/_2$-year period. Tests on fluids of various viscosities in structures having different orifices have shown that any desired time characteristic may be obtained. Pickup tests from 80 to 200 per cent of coil rating in the same unit show that such a unit may be used to replace both the old type thermal-magnetic and the so-called

"dual-magnetic" with one universal overcurrent trip unit.

The sturdiness of the new trip unit has been verified by its ability to withstand short-circuit currents up to 500 times the coil rating. It also has been verified by the ability of the sealed unit to withstand severe shock tests.

The ability of the sealed unit with its silicone fluid to maintain its characteristics throughout a long life is indicated by the operation of six units for over six months at a temperature of 150 degrees centigrade with no change in characteristics. Several units have had more than 1,000 overcurrent operations without change in characteristics and without noticeable wear.

Tests show that the device will operate at all temperatures from −40 to 100 degrees centigrade.

It is believed that these tests, when considered with the proved reliability of other hermetically sealed devices such as solder-sealed capacitors and treated and sealed transformers, prove the complete adequacy of the new tripping device for the service intended.

Power System Governing

T. E. CURTIS
ASSOCIATE AIEE

A governing system is proposed which is believed capable of accomplishing optimum and inherent load division among generating stations without dependence upon load telemetering systems. The primary objective of this article is the invitation of discussion which can guide further development of such a system.

THE PROPOSED governing system is based upon the concept that optimum division of load among generating stations is inherent if integrated frequency variations from standard time are controlled within limits of the same order as transmission-line torque angles. In other words, if generators are controlled so that power output decreases as the generator voltage increasingly leads the voltage of a reference frequency standard, then generators will divide load as a function of their relative electrical proximity to load centers. The fraction of the load assumed by the nearest controlled generator will increase as the power response per electrical degree is increased. It appears that load division of this nature is highly desirable for power system governing in general.

It is believed that the following objectives can be achieved:

1. Optimum division of load among controlled generating stations without dependence upon load telemetering systems.
2. Governing action which contributes directly to stability of transmission systems.
3. Maximum independence of control units at individual generating stations.
4. Unprecedented precision of power system time.

MECHANICAL ANALOGY

Figure 1 employs the classic mechanical analogy[1] of the electric transmission line in order to illustrate the proposed governing system. Each electric tie line is represented by two cranks of radii representing the terminal vectorial voltages, with an interconnecting spring whose modulus represents electrical reactance of the tie lines. Generators are represented as flywheels with moment of inertia[2] WR^2 connected to local loads and to tie lines. The entire system is considered to be rotating at synchronous speed. Governors are considered as controlling the driving torque supplied to each flywheel, while loads apply restraining torques in proportion to the magnitude of the load. Damping is not shown. Supply of a common reference frequency standard to each generating station is represented by a shaft driven by a constant speed device. Each generating station is provided with a differential device which yields the angular difference ϕ between the generator shaft and the constant speed device. ϕ may be defined as the *absolute torque angle* of the power system at a particular point. Thus, on the vectorial representation of the tie line between generator 1 and generator 2, ϕ_1 is the absolute torque angle of generator 1. ϕ_1 is the phase angle between vector $\mathbf{F}$, representing the constant speed device, and vector $\mathbf{E}_1$, representing the terminal voltage of generator 1. ϕ_1 is arranged to control governor 1 so that the power output of generator 1 decreases as $\mathbf{E}_1$

Based upon a conference paper originally presented at the AIEE Pacific general meeting, San Diego, Calif., August 26–29, 1947, and revised by the author in accordance with discussion and criticism of the paper at that meeting.

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increasingly leads **F**. ϕ_2 and ϕ_3 similarly control generator 2 and generator 3. It follows that this characteristic will cause the generator nearest a load change to assume most of the change. The basic tendency of the governing system is to minimize torque angles (δ) of tie lines. Therefore, such governing would contribute directly to the stability of transmission systems.

POWER SYSTEM TIME PRECISION

The proposed governing system requires a great improvement in power system time precision over that currently obtained. It is believed that the required precision of integrated frequency can be realized by application of $d^2\phi/dt^2$ as a component of control. Thus, $d^2\phi/dt^2$ is an immediate and accurate indication of the change in generated power necessary to restore equilibrium. Furthermore, it has been pointed out that application of angular acceleration as a component in a speed control system comprises a powerful antihunting means.[3]

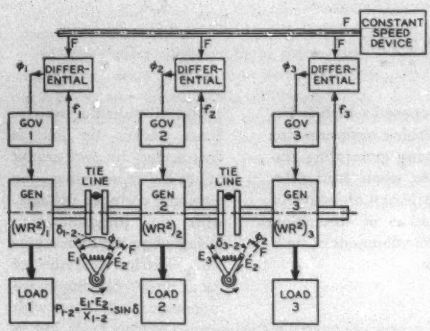

Figure 1. Mechanical analogy of proposed governing system

Several electronic devices have been developed for the purpose of measuring the rate of change of power system frequency with respect to time. One of these was developed by Gunnar Svala, in co-operation with Nydqvist and Holm Aktiebolag, at the Royal Institute of Technology, Stockholm, Sweden. Another was developed by the author[4]. Study of these two electronic systems indicated that they are not suitable for the governing system proposed herein. A derivative-computing servomechanism has been constructed, preliminary tests of which indicate that it is adequate for the requirements under consideration. This servomechanism is designed to receive an input f from the power system, and an input F from a frequency standard, as indicated in Figure 2. Given these two inputs, the servomechanism continuously yields outputs $d^2\phi/dt^2$, $d\phi/dt$, and ϕ, where ϕ is the electrical phase angle between voltages of f and F, and where t is time. Reference frequency F may be supplied at each governing station by a primary frequency standard. Alternatively, the reference may be transmitted over communication channels from one standard to all governing stations.

CONTROL COMPONENTS

The three outputs of the derivative-computing servomechanism are transmitted to the synthesizing computer, together with auxiliary control component P. P represents the electric power output of the governed generator. The synthesizing computer applies constant factors a and b to control components $d^2\phi/dt^2$ and $d\phi/dt$, respectively. The setting of factor a is determined by the effective inertia, so that component $a \cdot d^2\phi/dt^2$ is an accurate and nearly instantaneous *load change order* to the governor.

Obviously, component $d\phi/dt$ is functionally equivalent to the centrifugal governor. Where the sensitivity of a centrifugal governor is adequate, factor b may be set at zero. It is suggested that component $d\phi/dt$ may be used to good advantage for automatic supervision of control by means of continuous automatic comparison of $d\phi/dt$ against the output of the centrifugal governor. These two quantities should track with each other within very small deviations, except when troubles might develop in the derivative-computing servomechanism. Thus, arrangement could be made to permit fully automatic governing only so long as the derivative-computing servomechanism checks continuously with an independent centrifugal governor.

Control component α is a compound quantity, comprised principally of $c\phi$. Component α is intended to meet three requirements:

1. Adjustable power response with respect to absolute torque angle.
2. Adjustable power level.
3. Compensation for possible long time lags in prime mover response.

Adjustable power response with respect to absolute torque angle is possible by setting of factor c. Adjustable power level can be provided by adding a component Δ to $c\phi$. Thus, Δ in $c\phi+\Delta$ may be set to yield a desired normal load level of a generating station which is remote from a load area with a local generating station. Factor c at each controlling station would remain separately adjustable for desired division of load changes. Compensation is necessary in order to enable governors to act "intelligently" even though possible long time lags in prime mover response may cause the normal limits of absolute torque angle variations to be exceeded. Further discussion follows in connection with the synthesizing computer.

DERIVATIVE-COMPUTING SERVOMECHANISM

Figure 3 is a functional diagram of the derivative-computing servomechanism. The power system fre-

quency f is compared against a reference frequency standard F through a series of three self-synchronizing units.[4] The zeroing and stabilizing self-synchronizing units are driven in such a manner that the comparing self-synchronizing unit tends to keep the θ contacts open. When the actual phase angle between f and F does not track with the computed angle introduced into the self-synchronizing system, the θ contacts close to operate the input servomotor. The input servomotor changes the input to the first integrator in the direction and amount necessary to restore tracking between the computed ϕ and the actual ϕ, whereby the contacts reopen and the input servomotor stops. The input servomotor positions a splined wheel by means of a lead screw and wheel guide. The splined wheel is driven by friction from a disk rotating at constant speed ω. The displacement of the splined wheel from the center of the disk represents $d\phi^2/dt^2$. $d^2\phi/dt^2$ is integrated to $d\phi/dt$ by transmitting the rotation of the splined wheel to the second integrator. In the second integrator, $d\phi/dt$ is represented by displacement of the splined wheel from the center of the disk. Rotation of the splined wheel of the second integrator represents ϕ. Tests proved that two stabilization loops were essential for stable operation of the servomechanism. These stabilization loops introduce slight modifications in the computed outputs. Inasmuch as these modifications were observed to be insignificant during preliminary tests, they are neglected in the present considerations.

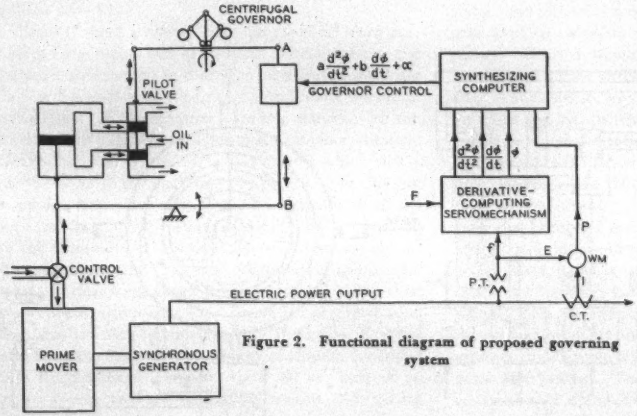

Figure 2. Functional diagram of proposed governing system

SYNTHESIZING COMPUTER

The three outputs of the derivative-computing servomechanism are transmitted to the synthesizing computer, shown in Figure 4. The synthesizing computer is intended to permit setting of the components of control for any particular conditions, and to synthesize all components into a single governor control output. This output is intended to be an accurate load order which the governor should follow. The a set provides means for setting factor a to yield a desired power change in response to $d^2\phi/dt^2$. As has been noted, a is determined principally by the effective WR^2. If the governor is equipped with adequate flyball governor, b may be set at zero. The ratios of load division among generators is determined by the setting of c. Thus, higher values of c will cause generators nearest loads to assume greater fractions of the load. Where it may be desired to increase the normal power transmitted from a remote generator, Δ may be inserted in the load level set.

The torque angle element interprets inputs $c\phi+\Delta$ and mP into a single output α. Normally mP will not influence α, so that,

$$\alpha = c\phi + \Delta$$

However, provision must be made to prevent over-controlling by the $c\phi$ component when the prime mover response lags excessively behind the load order transmitted to the governor. To this end, the torque angle element is intended to permit response to the $c\phi$ component only so long as mP tracks with $c\phi+\Delta$ within a limiting angle β, as illustrated in Figure 5. The rotating arm $c\phi+\Delta$ is energized from the a-c source through a commutator segment of arc β, rotated by mP. The arm moves a contact between two additional commutator segments, arranged to operate the α servomotor so that the small gap between the two segments follows the arm. The output α is obtained from this follow-up action. Rotation of α is stopped when mP lags far enough for the arm to break contact with the β segment. Thus, α is held in a desirable "biasing" position until mP catches up again. The α servomotor is interlocked further through a $\phi/60$ contact which prevents further change of α even though power response may be delayed sufficiently for the system to lose or gain a number of cycles. Arc t would correspond to a system time deviation of approximately one cycle, or 1/60 second.

SUMMARY

1. A governing system is proposed which is believed capable of accomplishing optimum and inherent load division among

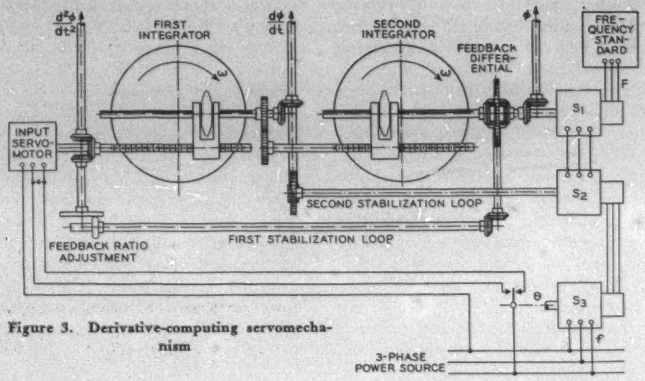

Figure 3. Derivative-computing servomechanism

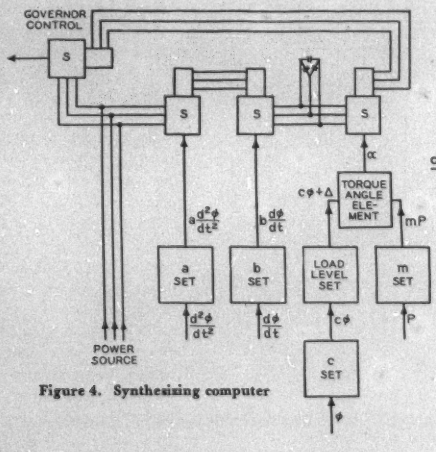

Figure 4. Synthesizing computer

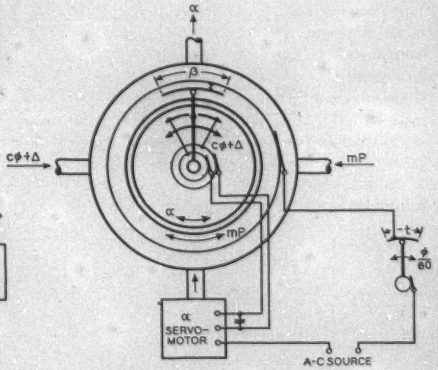

Figure 5. Torque angle element

generating stations without dependence upon load telemetering systems.

2. In accomplishing inherent load division, unprecedented precision of power system frequency and time would be attained.

3. Governing action of the proposed system would contribute directly to stability of transmission systems.

4. It is possible that smaller increments of power may be required to compensate for load changes, since the "sag" of the system can be reduced by the high-speed application of computed load orders to governors.

5. It is considered important that the proposed governing system should be capable of acting "intelligently" even though the limits within which it normally is expected to operate may be exceeded. General discussion of this phase of the problem particularly is desired.

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The Japanese Electric Power System

E. J. BURGER
MEMBER AIEE

A 5-member commission of which the author was a member was sponsored by the Secretary of War to prepare a study of the Japanese electric power system. After 4½ months in Japan, the commission made recommendations to General of the Army Douglas MacArthur with respect to reparations. This article stems from the author's experiences in examining the Japanese utility systems.

FOUR MAIN islands comprise the nation of Japan: Hokkaido on the north; Honshu, the large central island; Kyushu on the south; and Shikoku, an island off the southeast coast of Honshu. On these islands, which total about 140,000 square miles, live more than 75 million people. The population has increased by more than 15 million since 1927.

There is much evidence that the Japanese were preparing for a major war as early as 1939—we know the Japanese government in that year set about to integrate its power system which then comprised many operating companies. A government mandate resulted in the formation of the Nippon Hassoden Company (Electric Generating and Transmission Company) which was a merger of all of the operating companies. The Nippon Hassoden Company now owns and operates all of the Japanese generating stations above 10,000 kw and all of the transmission facilities. Power is generated and transmitted to nine "haidens" (distribution companies) which in turn resell power to the customers within their respective distribution areas. There is one distribution company on each of the islands of Hakkaido, Kyushu, and Shikoku, while the main island of Honshu is divided into six distribution areas. About 80 per cent of all power is generated and utilized on Honshu. The system established its all-time generating record in the latter part of 1943 when the Japanese war was at its height and early 1944 with generation at the rate of about 40 billion kilowatt-hours per year. This generation would indicate a total system demand of about six million kilowatts.

Taking into account losses on the Japanese power system, the total utilization of power for the peak year was in the neighborhood of 29 billion kilowatt-hours. It is interesting to note that only three billion kilowatt-hours were used by residential and small commercial customers in that year. Service to residential and commercial customers is not as a rule metered—each being billed on a flat rate basis and limited to one or two lights of small wattage. Electrical service used by commercial and domestic customers is limited despite the fact that nearly every home and store in Japan is wired for service.

After peace, it is estimated that the requirements for the public utility system will be 27.6 billion kilowatt-hours with a maximum demand on the public system of 4½ million kilowatts. No account is made here of the power to be generated by privately owned steam and hydroelectric plants. Table I shows the relationship between the actual generation statistics 1943 and those estimated after a reasonable length of time has been allowed for plant and system rehabilitation.

The Japanese power system is neither "man or beast," it is neither nationalized or is it a completely free enterprise system. The Nippon Hassoden Company and each of the nine haidens are corporations. But the Hassoden Company is not permitted to run its affairs on a free and independent basis. Instead, the electric power board, which is appointed by the Ministry of Commerce and Industry, joins officials of the Hassoden Company to form the administrative body and also exercises the prerogative of selecting its president. The board also assumes considerable authority in the operations of each of the nine haidens. This arrangement is unquestionably responsible for many of the shortcomings of the Japanese power system. For example, it is the custom of the electric power board to license and rate the plants constructed by the power companies. The capacities assigned, called authorized capacities, to many of the plants are at great variance from the actual capacities.

There are 66 public steam power plants of over 2,000 kw with total authorized capacities of 2,866,850 kw—but with total name plate ratings of 3,304,060 kw—notwithstanding the actual capabilities total 2,653,000 kw.

HYDROELECTRIC SYSTEM

There are approximately 1,284 hydroelectric plants in the public system:

Nippon Hassoden	388
Nine haiden companies	879
Semi-state-controlled utilities	16
Ministry of Transportation	1
Total	1,284

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The author wishes credit given to several people who contributed data used in this article: Toshio Yoshioka, Economic Stabilization Board, Tokyo, Japan; Masato Hirano, Nippon Hassoden Company, Tokyo, Japan; and Vaughn Pierce, Office of Supreme Commander, Allied Powers General Headquarters, Tokyo, Japan.

All plants of 10,000 kw and over are owned and operated by Nippon Hassoden, the largest being the Shinanogawa with 165,000 kw of installed capacity. This plant is located in the Niigata Prefecture on the Shinano River.

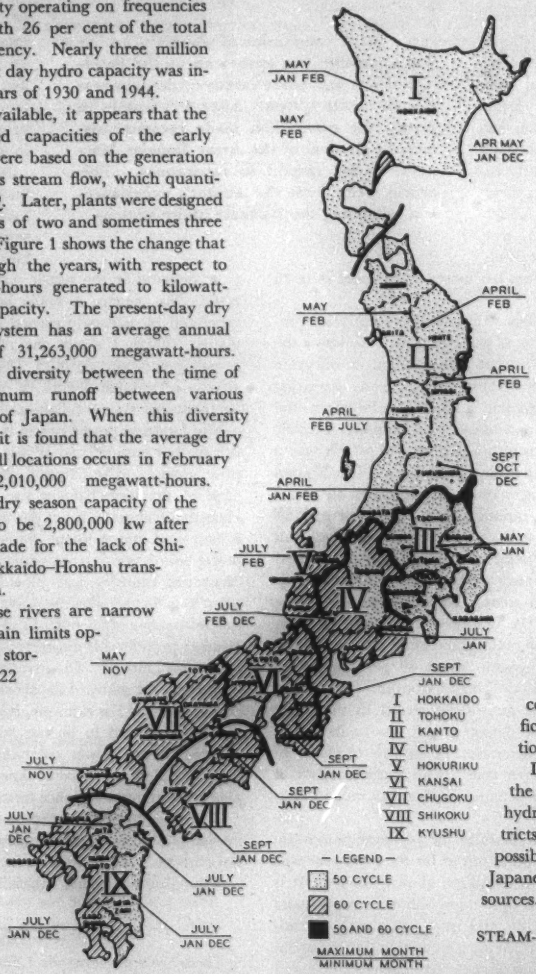
The public hydroelectric system has 5,815,900 kw of installed capacity operating on frequencies of 50 and 60 cycles, with 26 per cent of the total capable of dual frequency. Nearly three million kilowatts of the present day hydro capacity was installed between the years of 1930 and 1944.

From information available, it appears that the design and authorized capacities of the early hydroelectric plants were based on the generation available from 355 days stream flow, which quantities were designated *1-Q*. Later, plants were designed and rated on the basis of two and sometimes three times the *1-Q* values. Figure 1 shows the change that has taken place through the years, with respect to the ratio of kilowatt-hours generated to kilowatt-is hours of installed capacity. The present-day dry season hydroelectric system has an average annual generation capacity of 31,263,000 megawatt-hours. There is considerable diversity between the time of maximum and minimum runoff between various geographical sections of Japan. When this diversity is taken into account, it is found that the average dry season generation for all locations occurs in February and approximates 2,010,000 megawatt-hours. Therefore the actual dry season capacity of the system is calculated to be 2,800,000 kw after allowance has been made for the lack of Shikoku–Honshu and Hokkaido–Honshu transmission interconnection.

Most of the Japanese rivers are narrow and swift and the terrain limits opportunities for seasonal storage. Records reveal 22 storage installations with total capacity of 1,800,000 acre-feet of water or 1,200,000 megawatt - hours.

The Japanese hydro plants are well designed and well constructed; however, the type of construction is in many ways different from hydro practice in the United States. The danger of earthquakes is ever present and as a result low-gravity-type dams are used, usually placed near the head waters. The diverted water then is led through tunnels or penstocks to the plant, located some distance below the dam in order to provide head.

Nine developments in Japan might be classified as operational storage type. Although these developments total 130,000 acre-feet, some of the capacity has been lost due to silting. Log chutes and fish ladders are provided but the former appear to be rather narrow. The fish ladders contained in the higher dams seem inefficient. Principal troubles have resulted from undercutting in many of the dams by flood flows discharged by spillways and emergency gates and failure to provide emergency power supply to operate spillways and gates at flood stage resulting in damage. Little attention has been paid to friction losses in penstocks, as indicated by frequent breaks in the hydraulic gradient, with a corresponding loss in efficiency from encrustation.



In Table II are listed the total capacities of the hydroelectric plants by districts and the maximum possible development of the Japanese hydroelectric resources.

STEAM-ELECTRIC GENERATING PLANTS

Except on Kyushu, the base power load is carried with hydroelectric power. Hydro plants on Honshu also are located in the northern mountainous areas and are connected by transmission lines to the load centers and points where steam plants are situated. The steam plants on

Table I. Actual and Estimated Generating Statistics

	Estimated Post Peace	Actual 1943
Public utility generation, billion kwhr	27.6	35.0
Private plant generation, billion kwhr	4.7	5.5
Total generation, billion kwhr	32.3	40.5
Max public utility system demand, megawatt-hr	4,500	6,000
Total utilization after losses, billion kwhr	25.8	33.2
Power sales public utility, billion kwhr	17.5	24.7
Residential and commercial, billion kwhr	3.6	3.0
Total utility sales, billion kwhr	21.1	27.7

Honshu are used to augment hydro generation about four months for an average hydro year. However, on the island of Kyushu where there is insufficient hydro capacity, the base load is carried by steam plants. The hydro development on Kyushu is in the southern and easterly section, whereas industrial development and the steam plants are mostly located in the north and west.

No wide difference exists between the design of steam plants constructed since 1930 in Japan and practice in the United States for the same period. However, because of difficulties in forging boiler drums, steam pressures above 50 kilograms per square centimeter have not been attempted. Steam temperatures for the more modern plants range from 400 to 453 degrees centigrade. All plants of this period are fired with pulverized fuel, using Fuller ball or Lapulco roller mills. Turbines, generators, condensers, boilers, and all other auxiliaries in the modern plants are of Japanese make. Two companies dominate the field: Ishikawajima–Shiboura and Mitsubishi. The largest plants constructed to date are in Amagasaki City near Osaka, known as Amagasaki 1 and 2. Plant 1 contains six 62,500-kva units each with a 4,280-kva house generator mounted on the same shaft. Amagasaki 2 has four 75,000-kw units, two of which were manufactured by Mitsubishi and two by Ishikawajima–Shiboura. This plant was started in 1937 and finished in 1941, and was reported to have a gross thermal efficiency of 24.5 per cent. The Mitsubishi turbines water rate at 60,000 kw is 4.2-kilograms per kilowatt-hour, whereas the Ishikawajima turbines have slightly higher rates.

Table III indicates the total capacities of the steam-electric plants in the public system.

Plants constructed prior to 1930 contain a mixture of foreign equipment: Westinghouse, General Electric, Metropolitan Vickers, and Ljunstrom manufactured in Sweden and in Japan. There is also some Swiss and German equipment. Stoker equipment in the early plants are of the green chain and underfeed types. The underfeeds were never very satisfactory because of the low grade of fuel available. However, the Japanese started building powdered fuel installations in the 1920's.

Turbine equipment was selected to obtain the highest possible efficiencies at the expense of durability. Turbine bucket peripheral speeds of 1,200 feet per second are common and it is noted that the cracked buckets are repaired by brazing strips into the cracks.

Two types of boilers are found in the Japanese plants: sectional-header straight tube, and the bent tube Garbo and Yarrow designs. Both types are manufactured by the Japanese. All of the boilers constructed since 1930 are equipped with Bailey water tube walls. In the higher pressure boilers the drums are forged with welded heads.

Almost all turbines are equipped with double condensers to reduce the outage time during cleaning periods. Most Japanese plants secure cooling water from tidewater basins resulting in sea water corrosion in the condenser tubes.

The quality of Japanese coal gradually has been deteriorating. Most steam plants were designed to use coal of about 6,000 kilogram-calories per kilogram, some of which came from Kyushu and Manchuria. Since the war there has been no coal exported from Manchuria to Japan and the Kyushu coal has been reduced greatly in quality. The average heat value of coal now in use in the Japanese power plants is about 5,000 kilogram-calories per kilogram.

Mill capacities are limited because of low heat value coal and high ash content. Power consumption on the mills runs from 15 to 25 kw per ton of coal pulverized. Rolls last about 5,000 hours and rings about 13,000 hours.

During the wet hydro season power is generated in the hydroelectric plants and transmitted at 154,000 volts to the load centers. This requires the operation of considerable power factor correction equipment. In addition to the installation of static capacitors, nearly every steam plant during the wet hydro season has one or two turbines disconnected and operating as synchronous

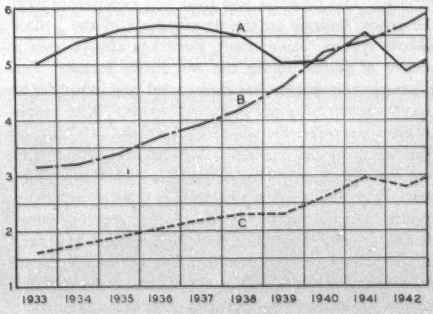


Figure 1. The Japanese hydroelectric system

A—The ratio of kilowatt-hours generated to kilowatt capacity (multiply by 10^3)
B—Kilowatts of authorized capacity (multiplied by 10^3)
C—Annual kilowatt-hours generated (multiply by 10^{10})

Table II. Hydroelectric Generating Capacity

Japanese Public System
May 31, 1947

District	Authorised Capacity, Kw	Approximate Per Cent 50 Cycles	Approximate Per Cent 60 Cycles	Approximate Per Cent Dual Frequency	Firm Capacity, Kw	Storage-Type Plants		Total Undeveloped Hydro Max, Megawatts	Undeveloped Firm, Megawatts Capacity	Total Hydro Max	Ultimate Firm, Megawatts Capacity
						Acre-Ft	Megawatt-Hr				
Hokkaido	226,600	85	1	14	106,000	481,000	203,570	1,256	400	1,482	506
Tohoku-Kanto	2,384,400	83	3	14	1,430,000	755,000	903,300	3,919	1,122	6,303	2,552
Kansai	2,218,800	6	55	37	870,000	523,000	93,600	6,169	2,190	8,387	3,060
Chugoku	297,600	0	100	0	132,000	0	0	747	264	1,044	396
Shikoku	206,500	0	100	0	100,000	0	0	711	195	917	306
Kyushu	482,000	16	37	47	230,000	0	0	895	302	1,387	532
Total	5,815,900	38	36	26	2,868,000	1,759,000	1,200,470	13,677	4,473	19,520	7,352

Note: Included: plants owned by Hasoden, 9 "haidens," Kurobegawa Denryoku, Sumitomo-Kyodo, Kanagawa Prefecture, Ministry of Transportation, and Mima SuiryokuKira.

Source of data: Electric Power Bureau.

condensers. Different methods are used in starting the generators. The most common method is using the house generator operating as a motor from an a-c source. In other words, the generators are started up simultaneously with another generator in the same station or in a near by station. About 700,000 kva of corrective capacity is required in the Osaka Kobe area.

DIFFERENCES BETWEEN AMERICAN AND JAPANESE PRACTICE

Although there are some marked differences between the actual physical equipment used by the Japanese in their power systems, the greatest difference lies in their concept of what we may term customer attitude. They do not feel the "fire department" responsibility toward the customer that is so inherent in American utility operators. The electric customer in Japan is subservient to the power company and is always thankful to be retained as a user of service.

There are several factors which contribute to this difference. The Japanese had their first experiences with the power business in the development of the hydroelectric system. As a result, there has always been a surplus of power during the wet hydro season. The Japanese management has encouraged new industries to use the surplus seasonal supply of power. Once a new seasonal customer was acquired, often through the application of special tariffs or otherwise, every effort then was made to supply him power throughout the entire year. Therefore, the power surplus quickly would be converted into a power shortage during the dry hydroelectric season. Customers with high seasonal load factor are given secondary consideration. There seems to have always been a power shortage during the dry seasons which manifests itself in a general power curtailment and reduced frequency.

In Japan it is impossible to rely on any appliance which is dependent on constant frequency. It is noted that, even in the wet season with an abundant power, the frequency may be anywhere from one to three cycles low. It is not uncommon to walk into a steam plant during a power shortage, and at a time when circuits are pulled, and find equipment designated as spare, remaining idle in the plant. In fact, it is believed that every steam plant retained surplus equipment beyond that required by good operating practice.

Another factor that contributes to the Japanese attitude toward the customer is government interference in business. Until recently the government subsidized the power companies by a guarantee of a minimum return. This policy removed from the power companies the responsibility of being self-reliant and has reflected itself in the attitude of management toward its customers and prospective customers.

As to equipment differences, several can be noted. In the power plants the operators show a reluctance to provide the usual and necessary experimental work on a new boiler installation to bring it to proper and often guaranteed performance. We know that it is the exception when a boiler, newly installed, performs as expected by its designers. It then becomes the duty of the operators, according to our practice, to make the necessary changes to provide maximum performance. It is observed that the Japanese operators will not make any material changes to remedy design defects or deterioration in coal quality in a boiler after it once is installed. As a result it is nearly impossible to find boilers operating up to design conditions.

Another contributing factor is lack of proper boiler maintenance schedules. This condition is very obvious in the Kyushu area where steam-generated power provides the base load. Here can be found probably the worst operated steam plants in the system. In one plant furnace fire could be seen through the boiler settings—tubes were dirty inside and out and often bagged.

Neither do the Japanese give the necessary attention to feed water treatment which also adds to their maintenance difficulties.

Turbine installations look much like ours except foundations are extremely heavy either on mats or piling.

Table III. Steam Generating Capacity of the Japanese Public System

District	Authorized Capacity, Kw	Per Cent 50 Cycles	Per Cent 60 Cycles	Name Plate Rating, Kw	Estimated Capability, Kw
Hokkaido	56,500	80	20	73,000	73,000
Tohoku-Kanto	428,800	98	2	464,500	349,000
Kansai	1,471,000	0	100	1,635,360	1,428,000
Chugoku	262,950	0	100	332,500	254,500
Shikoku	129,600	0	100	159,350	147,500
Kyushu	518,000	83	17	634,350	401,000
Total	2,866,850	25	75	3,304,060	2,653,000

Note: Included are plants owned by Ministry of Transportation and Sumitomo Kyodo (Nihama 2).

Source of data: Field inspections, The Japan Electric Generating and Transmission Company, Ltd., "haiden" companies, and the Electric Power Bureau.

Heavy building and foundation construction is designed to withstand earthquake shock. Standard practice in the Japanese plants is the use of steam air ejectors used with surface condensers instead of air pumps. The ejectors protrude up through the turbine room floors and are somewhat unsightly. It is also common practice to mount house service generators and double exciters on the main generator shafts. This arrangement results in units sometimes over 100 feet in length. At Amagasaki 1 with six units of 50,000 kw each placed end to end the turbine room is about 650 feet long.

Control and cable runs ordinarily are left exposed in trenches or open ducts, which both is unsightly and represents a real fire hazard.

High-voltage substation construction appears to be standard except the Japanese in most instances have held to minimum clearance in spacing of conductors and the location of apparatus. This practice probably stems from the necessity for conserving ground space. Substations have the appearance of being packed in too close for comfort. One substation was constructed completely enclosed in a steel frame building to avoid hazard from dirt and salt spray.

Usual practice in some of the later powdered fuel installations is the use of coal driers with capacities up to 20 tons per hour. The driers are designed to remove about 20 per cent moisture content from the coal.

Coal handling equipment is much more elaborate than that found in the United States. Where plants are located on navigable water, barge unloading facilities are provided. Coal then is handled by means of a multiplicity of belt conveyers and gantry cranes. At many plants undercover storage is provided. Despite all of the elaborate coal handling facilities installed, it is common to see coal being carried in bamboo baskets by women.

PERSONNEL

Management of the Japanese systems employ from 2 to $2^1/_2$ times as many people in the operation of similar size plants as in the United States. A typical example is the Ainaura Station in Kyushu with 65,000 kw installed capacity. This plant has a total working force of about 300 people. The union now is demanding that the personnel be increased to 492 based on a $5^1/_2$ day work week. At Tobata, also in Kyushu, with 160,000 kw of installed capacity, there are employed 760 people. The Japanese union requires that six operators be in attendance per turbine per shift, this requires a total attendance of 108 employees in the turbine rooms. In the boiler room is a total of 185 employees with nine men per boiler per shift. Sixty-seven employees are used for 3-shift operation for coal handling. The balance of the employees are used in maintenance and plant records.

The average pay is about 2,300 yen per month: the total days worked per year is 245. There are 104 Saturdays and Sundays, nine national holidays, five New

Figure 2. The Senju hydroelectric station serving the Ministry of Transportation contains four 30,000-kva generators

Figure 3. The turbine room of the Amagasaki 1 steam power plant, Osaka, Honshu, Japan

It contains six 50,000-kva Japanese turbines

Figure 4. Equipment used to dry coal en route to boiler room bunkers

Year holidays, and two local holidays. The present legal rate of exchange is 50 yen per dollar.

Local plant management cannot deal decisively with plant labor as is the custom in America. Personnel matters are referred to Tokyo for final disposition.

Graduate engineers in Japan are started at a management level justified by the grade of technical school from which they are graduated. It is not the custom to place technical men at levels where they may gain operating experience. It necessarily follows that many men are in management positions who never have had the benefit of actual operating experience.

Technically, the Japanese are very well educated and well grounded in the fundamentals of electrical engineering. They are both studious and ambitious. Many of them have received their technical training in some of our best engineering schools.

BOMB DAMAGES

Aerial bomb damage to the electric plants was slight in comparison to other industries. Hydroelectric plants suffered no war damage.

Major damage was inflicted on three large plants, in addition to two small plants that were demolished in Hiroshima and Nagasaki.

The worst damage from aerial bombing was inflicted on Amagasaki 2 near Osaka—fragmentation bombs penetrated the boiler and turbine rooms. Although considerable damage was done to two boilers, no turbines actually were destroyed. Parts of the building were damaged badly.

The 154-kv outdoor substation Amagasaki 1 was partially ruined—aerial bombs exploded the oil in the transformer banks which badly damaged other parts of the substation. The other two plants that suffered severe bomb damage were Tsurumi and Kowasaki. However, in neither case was the damage permanent. In other plants bombs had been dropped in the yards, inflicting minor damage.

It was observed that fragmentation bombs dropped through the roof of an electric power plant exploded eight to ten feet below the roof but did not cause serious damage to the apparatus.

Electric Drive for Aircraft

GEORGE C. CROM

AERODYNAMIC EFFICIENCY of very large high-speed propeller-driven aircraft could be increased substantially if the power plants could be moved out of the wings, thereby decreasing the size of the nacelles. In addition, a plan then might be worked out whereby each power plant could operate at its lowest specific fuel consumption point, with some units being shut down during low load periods. However, such a scheme is not feasible under current practice because of difficulties which would be encountered in transmitting mechanical power through flexible members. Stopping engines and feathering the propellers directly connected to them is a rather unsatisfactory method of reducing power, and can be quite dangerous in wartime.

The development of light-weight high-speed high-efficiency gas turbine power plants has introduced additional factors which make a central power system advantageous. Turbojet and turbopropeller engines operate a minimum specific fuel consumption over a very limited speed range. The inertia of the turbine rotor

Essential substance of paper 47-215, "Electric Drive for Aircraft," presented at the AIEE Middle Eastern District meeting, Dayton, Ohio, September 23–25, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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at its high speed is greater than that of a reciprocating engine driving a propeller.

A central electric turbogenerator system for very large long-range bombers can effect valuable fuel savings because the wings may be redesigned to have lower drag and the number of turbogenerators in operation at any time may be chosen so that each unit can operate at maximum efficiency.

ELECTRIC DRIVE

The obvious solution to the problem seems to be to separate the propeller and turbine, and transmit the power by electrical methods. The application of electric power transmission to aircraft is difficult and beset with many limitations.

The necessity for minimum weight without complication of apparatus design seems to indicate the use of induction motors at frequencies of about 400 cycles per second. The alternator design fits in well with the available gas turbine speeds of 8,000 to 12,000 rpm, using four or six poles, and letting the frequency be whatever is the result of the speed and pole choice.

PROPELLER MOTORS

A 6-pole induction motor seems to be the most practicable, giving some speed reduction with a 4-pole generator.

Ratings of induction motors to drive large propellers at slow speeds will be about 6,000 to 10,000 horsepower peak power for five minutes, based on four propellers per airplane and 250,000 to 500,000 pounds gross weight. The five minute rating is the usual take-off rating for maximum power. Diameters of such motors would be 28 to 34 inches, which can be buried in a wing or in a nacelle having a diameter equal to the wing depth.

OPERATION

The alternators as they are started would be synchronized manually or automatically and connected to the bus. Not having any load connected to them, the starting problem is simplified over that of the turbopropeller engine.

Probably it would be best to start the induction motors under reduced voltage and with a limited number of alternators connected to the bus. All four of the motors would be started one by one on, say, one or two alternators with the propellers set at position of minimum thrust. After the propellers are rotating at normal speed, the remaining alternators can be synchronized and connected to the bus. Governors of each turbine can be interconnected by the flight engineer so that the turbines will respond to the demand for power at constant speed.

The power delivered by the propellers is determined principally by the pitch angle for a fixed speed, including reverse pitch, and the propellers would revolve at substantially constant speed at all times, as the speed is fixed by the turbine governor on the automatic control. As the pilot advances the power control lever, the motors will deliver more power and that power will be delivered by the turbogenerators following standard power practice. Simultaneously, in accordance with signals received from electric power-sensing devices, the propeller blade pitch will increase to absorb this power and convert it to useful thrust.

Circuit breakers will have to be placed between the bus and each motor and each generator and possibly in such position to sectionalize the bus, and will be operated by the flight engineer.

Circuit breaker weights will have to be reduced below weights used in 60-cycle practice and may have to be pressurized. A 3-phase 4-wire system with neutral grounded (so that loss of one phase will not disable a motor propeller unit, but only lower its rating) seems best.

The details of the propeller and power control will have to be worked out. The necessity for brakes to stop rotation of a feathered propeller will have to be studied, as with no excitation of motor there is no retarding friction. Possibly, the excitation of one phase of the induction motor could be used as a brake. Rate of propeller pitch change will have to be co-ordinated with rate of power change of the governors and turbogenerators. A wattmeter will have to be in the line to each motor and an automatic or manual control will be necessary to change the propeller pitch angle in accordance with the wattmeter reading for a given power setting.

WEIGHT CONSIDERATIONS

Total unit weight from the alternator shaft to the motor shaft (motors, generators, wiring, and so forth) is estimated as 1.05 pounds per horsepower.

The net weight of the electric transmission system is large and its use only can be justified when there is a saving in weight because of the benefits of the system or other valid and useful features.

The flexibility of the electric system enables the aircraft designer to have more freedom as to placing of the propellers and their driving motors. There is no low-frequency vibration resulting from the motor and usually a thin wing and nacelle can be used with the motors, and with the turbines mounted in the fuselage, and their exhaust carried outside to add some thrust. This will create a reduction of drag which has been estimated by competent designers as having values of 8 to 12 per cent.

If the flight plan of the airplane includes large changes of power, such as extended cruise conditions at low power settings, some turbine units can be shut down and the four propellers set for lower power sufficient to operate the remaining turboalternators at full load, thus reducing the specific fuel consumption when compared with four turbopropeller engines. The larger the number of turboalternators on the aircraft, the greater the savings, as the number of power steps available will be larger and those in use can be operated at the full load.

Electric apparatus is limited in power output primarily by its ability to dissipate heat. It can stand severe overloads such as that required for take-off where the overload is necessary for only five minutes maximum. The continuous duty required will be that of the normal design of the electric motors, generators, and wiring. By reducing the generator and bus voltage for low power settings, the four induction motors can be operated at near full load current and thus have better power factors than if they were operated at full voltage and smaller load currents. The copper losses would be unchanged, but iron losses would be reduced.

A careful comparison of mechanical drive and electric drive was made by assuming a typical flight plan and calculating fuel consumption, weight of equipment, and so forth for each drive. The electric drive consumes only 88 per cent of the fuel consumed by the mechanical system, a saving of 10,720 pounds. However, the total weight of the electric-drive system exceeds that of the mechanical drive by 23,540 pounds. It is possible that weight savings can be made through improved design of the electric equipment, special design of gearing, reduction in fuel tank weight, and so forth.

CONCLUSION

Although the electric drive can be used only on very heavy long-range bombers having a wide power range in their operation, the increased flexibility of the system will prove to be a valuable asset. Even though it is heavy for use on small aircraft, cases may arise where the flexibility resulting from its use can be shown to overcome the resulting weight increases.

National Bureau of Standards Tube Research

The tube laboratory of the National Bureau of Standards is carrying on a basic and applied research program on vacuum tubes in collaboration with industry, for military and industrial uses.

The most significant contribution made by the tube laboratory so far is the development of new types of subminiature tubes in co-operation with private industry. In the course of this work, it was found that a tube one-fourth inch by one inch would perform specific functions just as well when simplified in certain ways. Simplification made further reduction in size possible, and the "micro tube," which is slightly larger than a grain of rice, was developed. Details on this tube, which has military applications, have not been released.

An interesting project is the work on long-life tubes that are being developed for use in electronic computing machines. Older models of such machines have utilized as many as 18,000 tubes, and some of the newer models require up to 2,000 tubes for a single machine. It is very important, therefore, to reduce tube failures to a minimum. These new tubes are expected to have a life of 15,000 to 20,000 hours, or 10 to 20 times the expected life of present-day computer tubes. They are being developed by a tube manufacturer working under a development contract.

Another co-operative project is the study of impurities in cathode structures. It has been known for some time that small amounts of impurities in the base nickel, such as iron, carbon, silicon, and manganese, affect the emissivity of an oxide-coated cathode in ways not yet completely understood. This matter was considered so important that the American Society for Testing Materials created a special committee with industry-wide representation to learn quantitatively the effects contributed by any particular impurity or combination of impurities. Tube manufacturers have approached this problem from a statistical point of view, hoping to obtain satisfactory data from a large amount of sampling.

The method proposed by the tube laboratory aims to reduce experimental variables to a minimum. This method is one of synthesis, in which carefully controlled amounts of the different impurities will be deposited, singly or in combination, directly in or upon the base nickel, thus eliminating many of the variable factors.

Another typical problem relating to applied research is the study of the phenomenon known as "gas clean-up," which refers to the disappearance of gas from a gas-filled tube. The investigation thus far indicates the anode as the probable recipient of the gas. It is thought that the gas ions strike the anode surface with sufficient force to penetrate the surface and remain lodged within the material. The release of this gas then can be effected only by heating the anode to a high temperature. If a way can be found to prevent gas clean-up, it will be possible to construct satisfactory low pressure tubes with higher inverse voltage break-down ratings.

The elimination of the phenomenon of "microphonics," which is caused by vibration of the internal structure of the tube, and is present to a greater or lesser degree in every vacuum tube, would solve many of the problems now confronting the manufacturers of electronic equipment. Incredibly small variations in the internal structure of a vacuum tube often will produce very great changes in operating characteristics. In addition, such a structure is inherently subject to many directions and amplitudes of vibration. These factors make the entire subject of microphonics an extremely complicated one. The laboratory has achieved important progress in this field but thus far the work has pertained only to secret requirements of the Armed Forces.

Solar Radiation

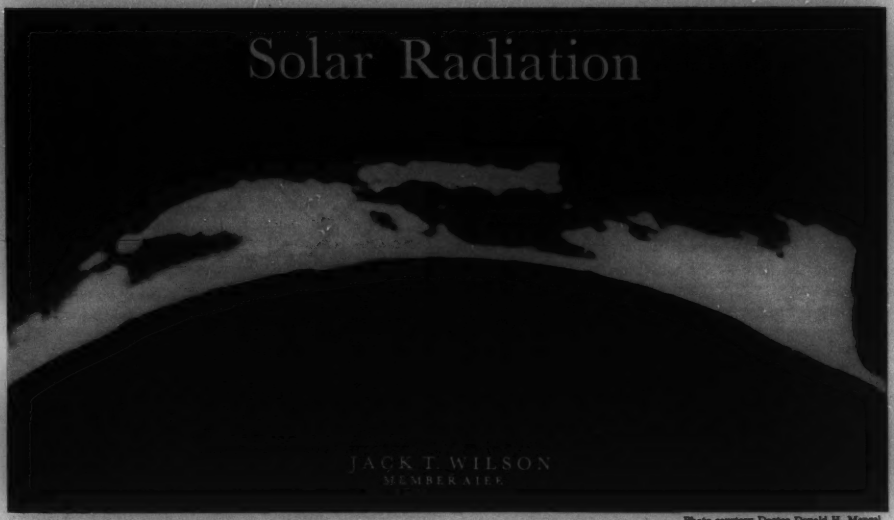

Photo courtesy Doctor Donald H. Menzel

This brief history of studies in solar radiation well may serve to re-emphasize the significance of both ancient and recent discoveries. The romance of these studies, however, should not overshadow the long hours of labor contributed to each investigation.

ALL of the great civilizations which have sprung up in the known history of the world, have recognized the sun to be the commanding influence which tempered the weather and caused the earth to yield up the grain which sustained them. Men devoted their days to the study of the sun and its position in the sky, and from these studies were derived the first calendars. The Egyptians devised a good calendar in the fifth century B. C., and from their observations they found knowledge which led them to predict the flood seasons of the Nile River, and as history handed down the traditions of the sun's behavior, an Egyptian prince, who lived in the time of Joseph, the son of Jacob, changed the state religion of Egypt to one of sun worship. In 317 A. D., the scholars of the Mayan civilization established their calendar and commemorated the solar events which they saw by erecting spendid monuments which today are found in Guatemala and Yucatan, and which tell the history of the rise and fall of this great section of the humanities.

We know of even earlier observers of the sun, because historic legend states that 1,600 years before the founding of the Mayan calendar, Asiatic astronomers and sun-watchers began to count their days from the time of solar eclipses and the seasons of the year known to be controlled by the positioning of the sky's golden orb.

With the growth of each civilization new methods have been developed for studying the sun, and scientists of the 19th and 20th centuries have become skilled in detecting many kinds of radiation which tell a rather complete story of the sun's behavior and its effect upon the earth.

The last half of the 19th century A. D. was filled with startling discoveries. In 1868, Professor J. Janssen, the French spectroscopist, discovered on the day following a solar eclipse that he could see the images of sun prominences by properly arranging the slit of his spectroscope to face the sun, and in broad daylight, without the aid of an eclipse, he saw the bright image of a tall prominence which he had seen the day before at the moment the moon blocked out the bright light of the sun's disk. A few days later, Sir J. N. Lockyear, of England, independently made the same discovery, and a new use for the spectroscope in studying the sun's condition had been introduced. These men who first attached the spectrometer to the telescope soon discovered that the sun's radiation was very similar to certain stars, and they realized very early that the sun belonged to the great family of stars which could be classified into groups according to the nature of light which they radiate. The astrophysicists have arranged the families of stars into the following main spectral classes: *O*, *B*, *A*, *F*, *G*, *K*, and *M*, with further decimal subdivisions which are

Full text of a conference paper, "A Brief History of Studies in Solar Radiation," presented at the Midwest general meeting, Chicago, Ill., November 3-7, 1947.

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designated $A_1 \ldots A_9$. This sequence of classification is set up in accordance with the effective temperature of the star with temperature decreasing from *O* to *M*.

Table I. Colors and Effective Temperatures of Each Spectral Class

Spectral Class	Color	Effective Temperature, C	
		Giants	Main Series
O	Blue		>30,000
B_0	Blue		23,000
A_0	Bluish-white		11,200
F_0	White		7,400
G_0	Yellow	5,500	6,000
K_0	Orange	4,100	5,100
M_0	Red	3,050	3,400

Table I shows that the sun belongs in spectral class *G*, and is thought to belong in the main series which is listed. This table indicates that the temperature of the sun's surface should be in the neighborhood of 6,000 degrees centigrade. In recent months solar studies have caused us to question this temperature value.

THE SPECTROHELIOGRAPH

Among the first great sun-watchers of the 19th century were Professor Hale of Chicago, Ill., and Professor Des Landres of Paris, France, who devised, independently, in the early 1890's, an instrument called the "spectroheliograph." This valuable tool made possible a clear picture of the sun's surface and the surrounding atmosphere. The essential feature of this wonderful instrument is similar to the focal plane shutter in modern camera construction. A narrow slit is provided in a curtain which moves in front of a photographic film in exact accordance with a collimator slit which moves in front of a prism of a spectrometer which, in turn, is attached to a telescope. The prism of the spectrometer separates out all light with the exception of that which is emitted as one bright line of hydrogen. (See Figure 1.)

For many years this astronomical tool provided pictures of the sun's prominences and told of the gigantic explosions taking place on the surface of the sun which threw out into space great clouds of luminous gas. Pictures of solar prominences made in 1895 by Professor Hale are still among the most beautiful that exist today, and the life cycle of a solar prominence could be studied in minute detail.

The details of the structure of the sun's corona, which is the halo of glory which surrounds the shining sphere of the sun, were studied best during the moments when the moon totally eclipsed the sun, and the path of total eclipse frequently passed over those parts of the earth which were quite remote from established astronomical observatories. In order to take advantage of these few brief moments when the sun's corona can be observed, expeditions have been organized and sent to various remote locations for purposes of setting up a temporary observatory for the eclipse. The Allis-Chalmers expedition of July 1945 was one of numerous expeditions which lined up their temporary observatories along the path of totality.

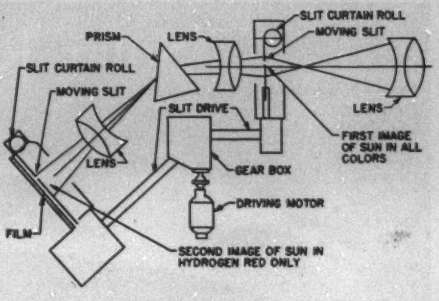

Figure 1. Schematic diagram of spectroheliograph

Slit curtains move synchronously

Total solar eclipses are not rare, and we may find that they average approximately one for every year and a half, but the duration of totality may be for as short a time as a few seconds. In some instances the period of totality is a little greater than five minutes. However, within such a short time for observation, numerous instruments must be operated with clocklike precision and the sequence of operation is important in gathering data concerning the sun's corona. Using such limited data, astrophysicists made remarkable strides during the last part of the 19th century in inferring the nature of the sun.

THE CORONAGRAPH

The next great step in the progress of studying the sun's behavior came about in the 1930's when two new observatories were erected in the high mountains and one in southern France for the purpose of studying the sun with a new instrument. This instrument, which is called the coronagraph, makes possible artificial eclipses of the sun at all times when the sun is visible. Professor M. Waldmeier, of the Zurich Observatory in Switzerland, designed an instrument which was mounted at Arosa, located at an altitude of 2,050 meters. Also, in the United States, at Fremont Pass, Colo., near the old mining town of Leadville, there was established an observatory under the direction of Doctor Donald H. Menzel of the Harvard College Observatory. The instruments in both the Swiss and American laboratories are based upon original designs of Bernard Lyot, who now is working with his coronagraph in France on solar studies. Waldmeier has continued his work in Switzerland which began in 1938, and during the recent war years much of the information coming from this laboratory has been unavailable to American scientists. However, a series of papers published in 1939 have given

valuable information concerning the Swiss research program.

The Fremont Pass Observatory, under the direction of Doctor Menzel and the able observations of Doctor Walter Orr Roberts, has contributed many new and valuable techniques of observation. These include the use of the movie camera which gives a record of the details of the behavior of the sun's corona and prominences.

The coronagraph is a type of camera which may be used to photograph the atmosphere surrounding the sun while the bright image of the sun is blocked out by means of a mirror located within the camera. In the schematic diagram of this instrument which is illustrated in Figure 2, an elliptical mirror* is placed in such a manner as to reflect the sun's image to one side so that the bright light of the sun is prevented from falling on the photographic plate and over-exposing the film. The reflected image of the sun is cast upon apparatus which is provided with water cooling, and, in this way, the intense heat can be dissipated without over-heating the instrument. The image of the sun's atmosphere passes the mirror and falls upon the sensitive photographic plate, and the details of solar prominence thus may be registered on the film. A system of filters is used in order to reduce the light coming from the sun and permit only certain wave lengths of light to pass through the instrument. In this way the bright images of the solar prominences are photographed in great detail, and, in some instances, the streamers of the corona can be seen upon the film. It is possible to attach a spectrograph to this instrument and study the physical and chemical nature of the materials which violently are being thrown off into space by the explosions which take place on or near the sun's surface. The headpiece of this article is a reproduction of a photograph taken with the Fremont Pass instrument.

The coronagraph is also a suitable instrument for plotting the intensity and type of radiation coming from the atmosphere adjacent to the sun's surface. As noted earlier in this article, for many years the surface temperature of the sun was thought to be in the neighborhood of 6,000 degrees centigrade. However, with spectrographic or selective filter techniques, we are able to show that very high energy must exist in the neighborhood above the surface of the sun. Doctor Menzel has shown recently that spectrographic record indicates that iron, which exists in the rare atmosphere of the sun, has been so distorted in its atomic structure that more than half of the planetary electrons which revolve about the nucleus of a normal iron atom have been blown from their place in the atomic structure. The energy required to hold an atomic structure in this state of excitement may be calculated, and the thermal environment necessary to support this state is greater than 1,000,000 degrees centigrade.

* The objective lens of the coronagraph brings to focus the image of the sun which occurs at the tip of the cone-shaped beam produced by the lens. The mirror is placed at an angle to the axis of the cone, and to intercept the sun image completely the mirror must have eliptical shape.

C REGION INVESTIGATIONS

One of the strongest emission lines which is seen with the spectrometer attached to the coronagraph has a wave length of 5,303 angstrom units. This line occurs in the visible spectrum and appears as a bright green to the human eye. The intensity of this wave length of light will vary considerably at different places in the sun's corona, and it has become possible to plot carefully the intensity emitted by all portions of the corona and calculate the kind of energy which is being radiated from the sun into various zones above the surface of the bright and shining sphere. On certain occasions we observe that the strong green line is emitted with abnormal intensity, and this intensity will be confined to a zone upon the surface of the sun. Waldmeier has called such zones the *C* regions, and he has shown that when a *C* region appears upon a side of the sun which is turning toward us, we may expect it eventually to face the earth, and a part of the intense energy which is being radiated in this region actually may reach the earth and produce measurable disturbances in our atmosphere.

The sun makes a complete rotation around its polar axis in approximately 27 days, and as the coronagraph gives a picture of the surface of the sun which is approximately 90 degrees from our line of sight, we realize that the sun will turn the surface which is observed by the coronagraph through an angle of 90 degrees in approximately seven days. If a disturbance appears on the surface of the sun which is turning toward us, we may expect to detect the disturbance by atmospheric effects in approximately seven or eight days. If a disturbance appears on the surface of the sun which is turning away from us, we may look back on records of atmospheric behavior and records of radio communication and possibly find indications that a disturbance occurred approximately seven days before the time of solar observation. A system for the keeping of records of such observed disturbances has shown that the earth's magnetic activity correlates to a surprisingly accurate degree with the behavior of *C* region emission as observed by the scientists using the coronagraph.

It has been well known for the past 25 years that most of the earth's magnetic disturbances tend to repeat themselves at 27-day intervals. Geologists also have become accustomed to the fact that terrestrial magnetic activity is characterized by 11-year cycles. These facts have led to the hypothesis that the sun may be responsible for these disturbances. For many years we observed spots upon the sun, and we began to believe that perhaps sunspot activity was in some way correlated with the magnetic disturbances. Attempts now are being made to correlate sun spots with *C* region activity, and as far as we know at present, *C* regions may occur independently and indifferently to sun spots. The correlation between

C region behavior and earth-magnetic activity seems to make more sense than any correlation with sun-spot activity which has been made up to the present time. However, we are in no position at this time to make a final statement concerning the relationship between sun-spot activity and earth-magnetic behavior. Only the most intense magnetic storms upon the earth appear to be associated directly with the sun spots. However, it has been observed that in some instances intense magnetic disturbances upon the earth take place approximately 27 days following the disappearance of a sun spot. This may mean that the area in which the sun spot occurred still is giving rise to intense radiation which may make itself felt upon the earth. In many instances the Swiss observatory has noted the correlation in terrestrial magnetic storms and *C* region erruptions (Figure 3[1]).

Other effects measured upon the earth seem also to be related to these frequently occurring flares of *C* region emission. A few recently observed measurements on ground potential gradient measure over a distance of 1,000 feet seem to indicate something of a correlation in terrestrial gradient potential changes and *C* region emission. This fact may be of tremendous significance to those engineers who are responsible for electric power transmission over considerable distances. If the value of ground potential can vary from place to place, it easily is seen how the circuit breakers in a power line distributing system may trip and cause frequent outages which have no apparent explanation in other types of circuit performance. The correlation of ground potential to solar activity can be made a major subject for study and research and at the present time it is only in its earliest infancy.

The air masses which move across North America seem to have certain characteristic electric potential gradients which change very slowly as the air mass changes its latitude of location. There is a general tendency for a potential gradient of air mass to rise as it moves northward and lower as it moves southward. Polar continental air masses generally decrease in their potential gradient from approximately 65 volts per meter at latitudes of approximately 50 degrees to gradients of 30 volts per meter at latitude of 40 degrees. Potential gradient may have some effect upon corona discharge which takes place on long distance power transmission lines. A program in research is indicated in this field.

Wind velocity appears to be an important factor in determining corona discharge, and knowledge of the relationships between wind velocity and corona discharge may point to important engineering practice in power line design.

The potential gradient of the earth's atmosphere is probably somewhat dependent upon the intensity of ultraviolet radiation coming from the sun and upon photoelectric effects which takes place in the atmosphere.

The Harvard Observatory group has shown that the

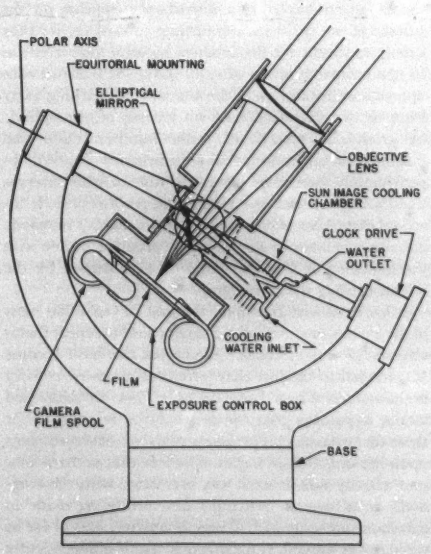

Figure 2. Schematic diagram of coronagraph

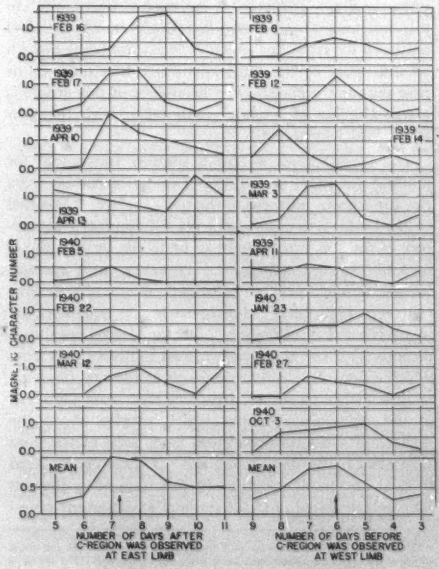

Figure 3. C region activity cycles

upper atmosphere contains strata of ionizing layers of air which serve as reflectors for radio-frequency beams. These strata reflect back to the surface of the earth certain wave lengths of radio energy which come from broadcasting stations. The reflecting layers of the earth's atmosphere behave in a manner similar to a lattice work. On some occasions the lattice spacings are of such size as most efficiently to reflect certain wave lengths of radio-frequency signals and permit other frequencies of radio signals to pass through and be lost in outer space. The spacing of this reflecting lattice seems to be dependent upon the intensity of solar radiation, and when the intensity is high the spacing is reduced and short wave lengths are reflected most effectively. When the intensity of solar radiation falls to a low level, the lattice spacings increase in value and longer wave lengths of radio signals will be reflected most efficiently while the shorter wave lengths will be passed by the lattice and lost. We can see how important exact knowledge of this fact must be, and in selecting broadcasting frequencies for communication to distant parts of the earth, we must take into consideration the solar radiation factor which is occurring at the given time of the broadcast. Doctor Menzel and Doctor Roberts contributed an outstanding service to the Armed Forces in World War II by assisting with the choice of radio frequencies which should be used for efficient communication with distant parts of the earth's globe, and the priceless value of this contribution should be recognized and assistance with their research program in this field should be granted willingly. Through the modest and sincere efforts of Bernard Lyot, M. Waldmeier, Doctor Menzel, and the excellent assistants which these men have had, knowledge of communication techniques has increased a thousandfold, and it is time we appreciate the value of this contribution.

RADIO INTERFERENCE

It may come as a surprise to many to learn that we have a new voice added to our range of perception—it is the voice of the singing sun! Doctor Menzel informs me that during the latter part of World War II, radio-listening stations were erected all over the world for purposes of detecting enemy signals and also for listening to the scrambled radio waves which were used by the enemy to confuse radar detection methods and radio communication used by the Allies. On certain days these listening stations heard wild sounds which seemed to come from a powerful broadcasting station that had not been detected as yet. Calculations were made to determine the electric power necessary to produce these signals, and it was shown that if all the broadcasting stations in the world were coupled together there still would be insufficient energy to produce the intense signal which occasionally had been heard.

It soon was learned that the sun was the source of this disturbance. From that time on, a few scientists have listened to the sun by means of short-wave radio receivers and a careful analysis of the signal which the sun gives off is being made. Certain types of radio receivers are capable of translating the sun's signal into audible sounds and the effect upon the human ear closely resembles a bird call. Special apparatus is needed for detecting the sun's radio signal and the antenna structure used is similar to radar reception apparatus used on shipboard and in aircraft units. Phonographic recordings of the sun singing have been made at the West Allis works of the Allis-Chalmers Manufacturing Company.

The sun broadcasts most frequently on the 200-megacycle band and sometimes produces an intense program at approximately 1,350 megacycles. Broadcasting stations upon the earth are monitored carefully and their signal is confined to a very small range of frequencies. The sun is not so careful, and a wide range of broadcasting frequencies may be heard which may extend from 50 to 500 megacycles. Sometimes weeks will go by and we receive no sound at all from the sun. Then suddenly, on some unheralded occasion, the sun will begin to whistle and sing and with microwave radio apparatus we are able to detect this activity.

Our increasing knowledge of the sun and its behavior may help us forecast weather. This knowledge also can prove the theoretical physicist's assumptions concerning the activities of atomic structure. The sun is likely a giant sphere of nuclear transformation processes which keeps alive, itself, its family of planets, and it represents the same forces which are acting to support the existence of our neighbors in space—the stars.

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Global Geometry

The importance of studying the properties of surfaces and other geometrical bodies of higher dimension as a whole instead of studying their properties in a small region was stressed by C. B. Allendoerfer, Haverford College, in a paper, "Global Theorems in Riemannian Geometry," presented before the American Mathematical Society.

He pointed out that geometers in the past studied the local properties of space ("differential geometry") and also the properties of space as a whole ("topology"). We now can relate the two by showing the influence of local properties upon the character of the whole space.

One such connection relates the curvature of a space (a local property) with an integer, the Euler-Poincare characteristic of the space which describes one of its chief properties as a whole. For a sphere this integer is two, and for a torus (doughnut-shaped surface) it is zero. It thus follows that the average curvature of a sphere is different from zero, but that that of a torus is zero.

Rotor Removal From Large Machines

An apparatus which is sufficiently flexible to be readily adaptable for use with rotating machinery of various sizes and designs is claimed to permit safe and rapid removal of heavy rotor assemblies. Cribbing, rollers, large capacity hoists are replaced by equipment which is safe to operate, and which allows for a minimum chance of accident.

REMOVAL of rotor units, which often weigh as much as 50 tons, from large generators, motors, synchronous condensers, and other rotating machinery is a relatively difficult task because of the small clearances (usually less than one inch) between rotor and stator. Methods that have been used to accomplish the assembly and disassembly of machines with such large rotating parts often involve procedures employing wooden timbers or cribbing moved on steel rollers, hazardous to both men and machine. A recent invention of Arthur A. Corder of Vancouver, Wash., is claimed to provide a relatively compact, safe, and efficient means for accomplishing the dismantling, assembly, and servicing of heavy rotating machinery.

Operation of the equipment is demonstrated in the accompanying illustrations as the equipment was used in dismantling for overhaul a 35,000-kva synchronous condenser of the Bonneville Power Administration high-voltage system. Essentially the equipment comprises a system of bridges and jacks for supporting the rotor while the bearing pedestals are removed and the carriages are set in place; a shaft extension which permits the rotor to be supported as it is withdrawn from the stator; and two jack-equipped rail-guided carriages which support the rotor as it withdraws from the stator.

In Figure 1 a supporting bridge is being set in place preparatory to removing the bearing pedestal after the air house and end bells have been removed. One of these bridges is used at each end of the machine. Figure 2 shows the method by which one end of the rotor is supported by transverse beam, jacks, bridge, and jack-screw reenforcing legs for removal of the bearing pedestal and installation of tracks, supporting carriage, and shaft extension. After the bearing pedestal is removed,

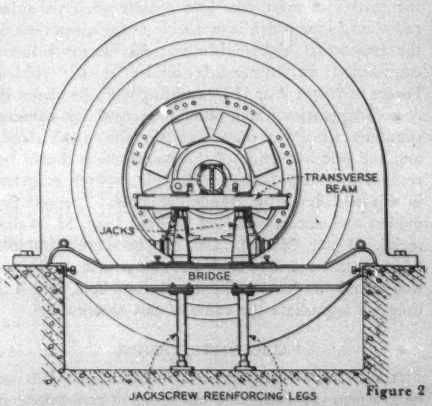
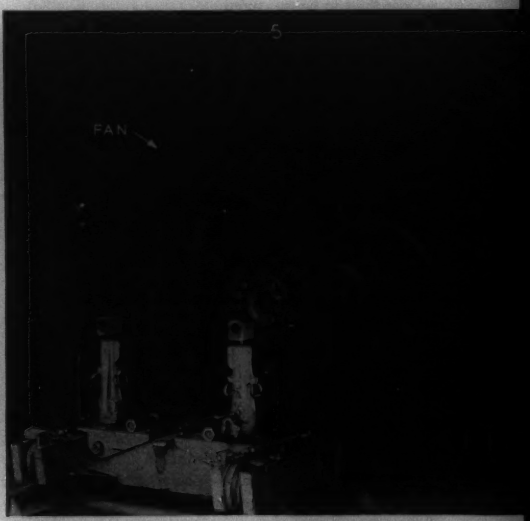
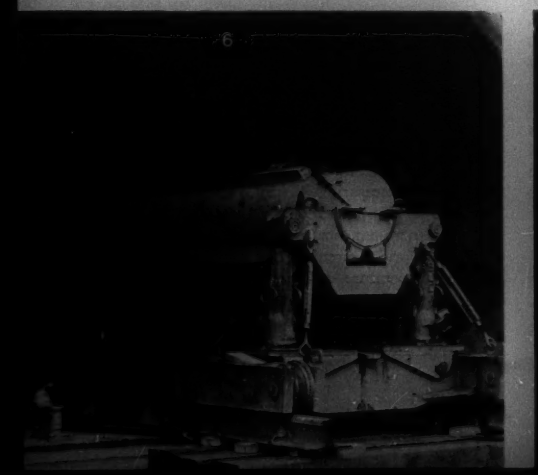


Figure 2

a short set of rails is laid and a jack-equipped carriage with the shaft extension is placed upon them as in Figure 3. When the shaft extension has been installed on the rotor shaft the weight of the rotor is taken by the carriage and the transverse beam and its supporting jacks are removed, but the bridge which supports the overhanging rail ends is left in place. Locking devices on the carriage wheels prevent movement when the opposite bearing pedestal on the collector-ring end is removed. The procedure for removal of the bearing pedestal at the collector-ring end of the rotor is the same as for the opposite end except that no shaft extension is used and a longer set of tracks is laid.

In order to remove the fan at the collector-ring end the transverse beam and jacks are removed (Figure 4), the fan is removed from the rotor and set on the carriage, and the transverse beam and jacks are replaced (Figure 5), and the carriage is withdrawn with the fan. When the carriage is replaced the transverse beam and jacks once more are removed and the rotor is withdrawn from the stator a distance equal to the carriage travel on the short set of rails (Figure 6). When the rotor has been withdrawn from the stator a sufficient distance the shaft extension is supported by the transverse beam and jacks while the carriage is removed from the short set of tracks and taken to the opposite side of the stator, placed on the rails, and set up to receive the rotor (Figure 7). The rotor may be moved away for servicing.





An Electric Flow Meter

J. H. LAUB
MEMBER AIEE

A new instrument for accurately measuring, recording, and controlling the rate of flow, as well as the total flow, of fluids applies an electrocaloric principle. A wattmeter is used to indicate and record the rate of flow and a watt-hour meter to register the total flow. The scale of the meter is linear and covers a very wide range.

THE commonly used types of flow meters for liquids and gases are based on "mechanical" principles such as the measurement of the pressure drop across an orifice or the displacement of a nutating piston, propeller, or vane inserted into the flow of the fluid to be measured. Frequently, the primary mechanical magnitude so measured then is converted into an electric signal for remote controlling or metering purposes.

The widely used pressure drop or head-type flow meter[1] measures the differential pressure head created by the passage of the fluid through an orifice, flow nozzle, or Venturi tube (Figure 1). This pressure head Δh is proportional to the square of the rate of flow M. A meter with a nonuniform scale results, therefore, whose range is rather limited. A number of methods have been developed for converting the square root relationship into a linear one to obtain a meter with a uniform scale such as the Ledoux-bell or special desquaring cams. A constant pressure drop is obtained in the rotameter by employing a float within a tapered glass tube which serves as an orifice with variable opening. Its position is read on a uniform scale, the range being limited by the length of the glass tube.

In flow meters of the mechanical type, auxiliary devices are required to convert the original magnitude measured, for instance, the position of a float or a vane or the speed of revolution of a propeller, into an electric signal if remote metering or controlling is desired. In flow meters of the volumetric displacement type, electric tachometers may be used, for example, as converters. In head-type flow meters a magnetic plunger frequently is connected to the float whose movement within an inductance coil unbalances an a-c bridge circuit and thus produces an electric signal.

It is apparent from this brief discussion that considerable advantages could be expected from a flow metering method which would eliminate

1. A nonlinear relationship between flow rate and measured value with an attendant gain in accuracy and scale range.

2. The need for converting a mechanical signal into an electric one.

3. Direct contact between the measuring elements and the fluid and difficulties which result from contamination, corrosion, or leakage.

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The author acknowledges assistance in the development of the new flow meter from John Kremer of the engineering department of Charles Engelhard, Inc.

THE ELECTROCALORIC METHOD

If heat energy is introduced into or withdrawn from a medium flowing within a conduit and its temperature measured before and after the heat exchange (Figure 2) the differential temperature Δt between the upstream and downstream thermometer readings will vary with the rate of flow. It will be small for high flow rates and large for low flow rates and if Q denotes the heat flow in gram calories per second through the thin walls of the conduit of small diameter of Figure 2, M the rate of flow in grams per second, c the specific heat of the fluid in calories per degree centigrade per gram,

$$Q = cM\Delta t \tag{1}$$

if heat losses by conduction and radiation can be neglected against heat convection by the fluid.

If Q is produced electrically in a heater coil wound in close thermal contact with the outside wall of the conduit and well-insulated otherwise, the wattage input W to the heater coil is proportional to Q,

$$W = kQ \tag{2}$$

and equation 1 becomes

$$W = kcM\Delta t \tag{3}$$

and

$$M = \frac{1}{kc}\frac{1}{\Delta t}W \tag{4}$$

From equation 4 it follows that if the wattage input W were kept constant and the temperature differential Δt measured, the rate of flow M would be inversely proportional to Δt and would have to be read on a meter with a nonuniform, that is, hyperbolic, scale. If, however, the temperature difference Δt is kept constant by varying the wattage input W to the heater coil, the rate of flow M is proportional to W and can be read on the linear scale of the wattmeter measuring W. This can be accomplished if, instead of the two mercury thermometers in Figure 2, resistance thermometers are used and connected to a Wheatstone bridge circuit which is kept in balance for a given temperature difference Δt. If the balance is disturbed by a change in the rate of flow M, it is restored by adjusting the wattage input W to the heater coil,

either manually or automatically. The resistance thermometers can be made, for instance, of nickel wire which has a high temperature coefficient of resistance and can be wound on the outside of the conduit in close thermal contact with its wall and well-insulated otherwise. A flow metering system thus is obtained, all of whose measuring elements are arranged outside of the fluid, which does not require conversion into an electric signal and which permits the rate of flow to be read on an instrument with a uniform infinite scale. It should be noted also that this flow metering system causes much less pressure drop in the line than mechanical flow meters of the pressure drop type.

Furthermore, totalizing of the flow can be achieved simply by adding to the heater coil circuit a watt-hour meter which then will register the total quantity of the fluid which has passed through the meter. This follows from integrating both sides of equation 4,

$$\int M d\tau = \frac{1}{k\varepsilon}\frac{1}{\Delta t}\int W d\tau \qquad (5)$$

if τ denotes the time.

The left side of equation 5 represents the totalized flow which is seen to be proportional to the wattage W integrated over any period of time and can be measured by a watt-hour meter.

Thus, we have arrived at a caloric electric system for measuring rate of flow as well as total flow, the basic elements of which are illustrated in Figure 3. A tube section *1* of a metal with high heat conductivity is inserted into the fluid line and thermally insulated from it by insulating spacers *2*. On it are wound a heater coil *3* and the downstream resistance thermometer *4*, both in intimate thermal contact with the outside wall of section *1* and well-insulated otherwise. The upstream resistance thermometer *5* is wound on the outside wall of the fluid line and is separated from section *1* by one of the insulating spacers. Thermometers *4* and *5* form two arms of a Wheatstone bridge, the circuit of which is completed by two fixed and thermo-constant resistors *6* and *7*, respectively, and by a Null indicator *8*. In series with the heater coil *3* are connected a current regulator *9* which may be operated automatically from the Null indicator *8*, a wattmeter *10* calibrated to read rate of flow, for instance in pounds per hour, and a watt-hour meter *11* which registers the totalized flow, for instance, in pounds.

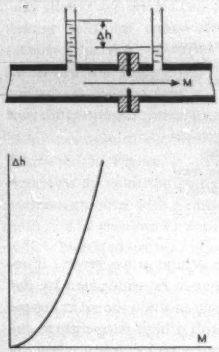


Figure 1. Relation between differential pressure and flow rate in a head-type flow meter

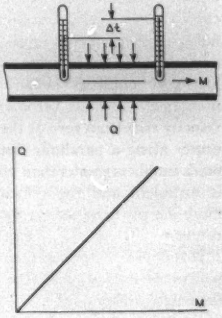


Figure 2. Relation between heat and flow rate in a caloric-type flow meter for constant differential temperature

SHUNT ARRANGEMENT

If large quantities of a fluid are to be measured, a substantial wattage would be required to maintain a satisfactory temperature differential Δt with the arrangement of Figure 3. This would necessitate a heater coil of large dimensions and thus introduce an objectionable time lag. Instead, the arrangement illustrated in Figure 4 is used for larger flows. A portion of the flow is shunted through a by-pass into which is inserted the section *1* carrying the heater coil *3* and the downstream thermometer *4*, again heat-insulated by means of spacers *2*. The upstream thermometer *5* now is wound on the main line and thermometers *4* and *5* again are connected into a Wheatstone bridge.

A small positive pressure head is maintained between inlet and outlet of the shunt by means of an orifice inserted in the main line a short distance ahead of the outlet. It will be noted that this arrangement is similar to the common shunt method of measuring large electric currents.

TEMPERATURE COMPENSATION

So far we have not considered the effect of varying fluid temperatures on the accuracy of flow measurements with the electrocaloric method. Referring again to equation 3 we note that wattage W and flow rate M are

proportional as long as the specific heat of the fluid remains constant. The latter is practically constant within a wide range of temperatures for most gases but varies somewhat for most liquids. For aviation gasoline of 0.702 specific gravity, for instance, the specific heat is 0.49 at 0 degree centigrade and increases proportionally with temperature to 0.55 at 50 degrees centigrade, that is, at the rate of approximately 1/4 of 1 per cent per degree centigrade.

Furthermore, we have to consider the effect of temperature on the viscosity of the fluid. It increases for gases and decreases for liquids with increased temperature, and thus affects, to a certain extent, the character of the flow and the mechanism of the heat transfer between the coils and the fluid. Without going into the details of the rather involved theory of fluid flow and heat transfer in pipes[3], a reminder that the local velocity of the fluid within a conduit is by no means uniform must be sufficient. The velocity distribution is governed by the Reynolds number which is inversely proportional to viscosity and therefore a function of fluid temperature. For Reynolds numbers below approximately 2,100, the motion of the fluid becomes streamline and the local velocity rises from zero at the wall to a maximum at the center along a parabolic distribution curve. For Reynolds numbers greater than approximately 2,100, the flow is turbulent and the velocity distribution curve rises more sharply from zero at the wall to a maximum at the center.

It is obvious, therefore, that the heat transfer from the wall to the fluid is affected by the character of the flow in the neighborhood of the wall, that is, by the temperature of the fluid. As a result of this, a flow meter as described

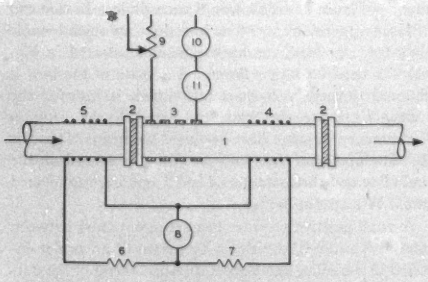


Figure 3. Basic elements of an electrocaloric flow meter

1. *Heater tube section*
2. *Insulating spacers*
3. *Heater coil*
4, 5. *Resistance thermometers*
6, 7. *Fixed resistors*
8. *Null detector*
9. *Current regulator*
10. *Wattmeter*
11. *Watt-hour meter*

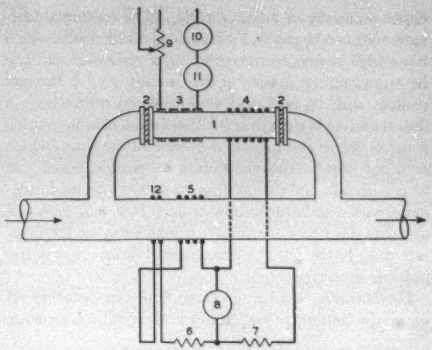


Figure 4. By-pass flow meter with temperature compensation

1. *Heater tube section*
2. *Insulating spacers*
3. *Heater coil*
4, 5. *Resistance thermometers*
6, 7. *Fixed resistors*
8. *Null detector*
9. *Current regulator*
10. *Wattmeter*
11. *Watt-hour meter*
12. *Compensating coil*

so far shows a considerable temperature error. Fortunately, the latter practically can be eliminated by the simple and purely electrical compensation shown in Figure 4. A small coil *12* of wire with a high temperature coefficient of resistance, for instance, nickel, is wound on the conduit and in intimate thermal contact with it. It is connected in series with the constant resistor *6* in one branch of the bridge and, as its resistance varies with the temperature of the fluid, the over-all effect is a slight shift of the bridge balance with temperature. This method of temperature compensation is so effective that in the previously cited instance of aviation gasoline, the temperature error can be held under $\pm$ 1/2 of 1 per cent within a temperature range from 0 degree centigrade to 50 degrees centigrade.

Variations of the ambient temperature will not affect the meter if the coils are heat-insulated well from the surrounding air and if the entire "transmitter" is enclosed in a metal cover which is in good heat-conducting contact with the pipe fittings and the fluid.

AUTOMATIC ELECTRONIC CONTROL

Rebalancing of the bridge is accomplished automatically by a simple electronic circuit (Figure 5). It consists essentially of a voltage and power amplifier in series which step up the signal from the a-c bridge sufficiently to operate a 2-phase reversible induction motor which drives the rheostat that regulates the current to the

heater coil. The second phase of the motor is energized from the a-c supply line, its current being displaced 90 degrees from the current in the first phase by means of the capacitor connected in series with it. As is well known, this arrangement has phase discriminating characteristics and the motor will reverse its direction of rotation when the signal from the bridge goes through zero and reverses its phase.

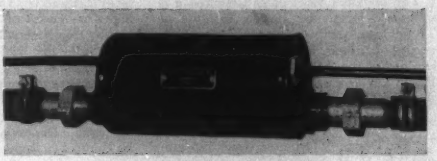
A similar arrangement is used for automatic control of the flow. In this instance the motor regulates a valve in the fluid line instead of driving the rheostat which then is set at a predetermined value corresponding to any desired rate of flow.

The electronic circuit described provides a continuous and very sensitive control that reacts immediately to minute changes in flow rate.

It should be noted also that fluctuations of the line voltage will not cause any error in indication. If, namely, the voltage varies the automatic control immediately will restore the wattage input to the heater coil which is demanded to maintain the fixed temperature differential Δt for a given rate of flow.

An example of the new electrocaloric flow meter is illustrated in Figure 6. The instrument shown is designed to measure the rate of flow and the total flow of aviation gasoline with a range from 0 to 2,000 pounds per hour. The transmitter consists of a by-pass arrangement with a 1-inch diameter main line and a 5/8-inch diameter shunt on which the heater coil of nichrome wire is wound. The maximum input to the latter is 50 watts corresponding to a flow rate of 2,000 pounds per hour. It is measured by a long scale indicating wattmeter[4] calibrated in pounds per hour. The watt-hour meter registers the total flow and is calibrated in pounds and the two instruments are mounted in the hinged front panel of the receiver case. The electronic control unit consisting of amplifier, motor, and rheostat is mounted inside of the case on the rear panel and is easily accessible.

A—Receiver



B—Transmitter

Figure 6. Electric flow meter for gasoline 0–2,000 pounds per hour indicates rate of flow on wattmeter and registers totalized flow on watt-hour meter

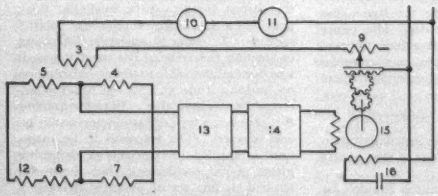


Figure 5. Automatic electronic control

3. Heater coil
4, 5. Resistance thermometers
6, 7. Fixed resistors
9. Current regulator
10. Wattmeter
11. Watt-hour meter
12. Compensating coil
13. Voltage amplifier
14. Power amplifier
15. Motor
16. Phase shifting capacitor

Transmitter and receiver can be separated by any convenient distance if remote control or metering is required without affecting the accuracy of the instrument. If a permanent record of the rate of flow is desired, a recording wattmeter of conventional design is used instead of the indicating wattmeter.

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4. **Advancement in the Design of Long-Scale Indicating Instruments, R. M. Rowell, N. P. Millar.** AIEE *TRANSACTIONS*, volume 66, 1947.

National Electronics Conference Technical Papers Digested

To give AIEE members an indication of the scope and nature of the 78 scheduled technical papers presented at the third National Electronics Conference held November 3–7, 1947, in Chicago, Ill., the following digests are offered. These are based mainly on information supplied by the authors.

None of the papers are individually available, though in some cases the authors may have extra copies for distribution. However, the majority of the papers are scheduled to be published in the "Proceedings" of the National Electronics Conference which is currently in production and should be available early in 1948.

Persons interested in securing copies of the "Proceedings" should forward their requests and a remittance of $4 for each copy requested to R. E. Beam, Secretary, National Electronics Conference, in care of the Electrical Engineering Department, Northwestern University, Evanston, Ill.

Copies of the 1944 and the 1947 "Proceedings" are still available and may be secured from the same source at $3 and $3.50 each, respectively.

The National Electronics Conference is sponsored jointly by Illinois Institute of Technology, Northwestern University, University of Illinois, and the national organizations of the AIEE and the Institute of Radio Engineers. The Chicago Technical Societies Council is a co-operating society.

NOISE SUPPRESSION, DISTORTION

"The Design of Dynamic Noise Suppressors," by H. H. Scott (M '38) of Hermon Hosmer Scott, Inc., covered the various factors entering into the performance, characteristics, and practical design of Dynamic Noise Suppressors. It was pointed out that by application of the dynamic-band-pass principle the Suppressor allows the attainment of a better signal-to-noise ratio than previously was considered possible. The design of these units requires careful matching of Suppressor characteristics to the rest of the reproducing system to obtain optimum performance.

The intermodulation method of audio distortion measurement was discussed in a paper called "An Analysis of the Intermodulation Method of Distortion Measurement," by W. J. Warren (M '46) and W. R. Hewlett (A '40) Hewlett-Packard Company, Palo Alto, Calif. The results obtained by the use of this method were compared with those obtained by the harmonic measurement method. Predicted values for percentages, intermodulation distortion, and harmonic distortion were given for several typical amplifier characteristics and were substantiated by test results. Formulas were given for approximate predetermination of percentage intermodulation distortion from current values on the transfer characteristic of a resistively-loaded tube. For more accurate prediction of percentages, intermodulation tables were included for calculation of the prominent components from 11 points on the transfer characteristic. Curves expressing the ratio of percentage intermodulation distortion to percentage harmonic distortion plotted against the latter summarized the results of the analysis. It was pointed out that these curves are useful for correlating the results of the two methods of measurement.

Some interesting information on signal-to-noise ratio was presented in a paper called "Basic Considerations on the Signal-to-Noise Ratio in Amplitude-Modulated Receivers," by E. C. Fubini and D. C. Johnson, Airborne Instruments Laboratory. The signal-to-noise ratio at the audio or video output of an amplitude modulated receiver often is assumed to be the same as the signal-to-noise ratio at the input of the second detector. It was pointed out and shown that this assumption was correct in the normal case of receivers for broadcasting and for other similar applications, but it is not correct when the intermediate frequency bandwidth is much greater than the video or audio bandwidths. Therefore these considerations were important only for very high frequencies or higher frequency systems. Experimental data were given to show how the audio or video signal-to-noise ratio changes as a function of the intermediate frequency bandwidth, the audio or video bandwidth, and the input signal.

"Corona Discharge at High Altitude and Its Control to Reduce Radio Interference" was the subject of a paper presented by H. J. Dana (M '45) State College of Washington, Pullman, Wash. It was pointed out that corona discharge at high altitude caused interference with radio navigation aids on aircraft and that there was a need to determine the basic laws governing this phenomenon. The paper covered the method of procedure, apparatus employed, and gave mathematical analysis of the results and compared them with other authorities.

ELECTRONIC INSTRUMENTATION

The subject of electronic instrumentation was discussed in two sessions of four papers each.

"Self-Balancing Thermistor Bridge" by Carl C. Bath and H. Goldberg (M '44) Bendix Radio Division of Bendix Aviation Corporation, Baltimore, Md. covered the use of thermistors for power measurement at radio and microwave frequencies. The paper described a bridge for use with thermistors having a number of interesting properties. It is automatically self-balancing and is temperature-compensated. The instrument is direct reading and has a scale that is linear with power. The maximum sensitivity is 35 microwatts full scale and the minimum sensitivity is one microwatt full scale. It has internal calibration means. Depending on the thermistor mount used, power measurements may be made from the low radio frequencies to the highest microwave frequencies. The instrument employs two matched thermistors, one of which is fed the radio-frequency power. This thermistor is part of a bridge which is in the feedback loop of a 6-kc sine-wave oscillator. The other thermistor which is exposed to the same ambient temperature is part of an identical bridge which is in shunt with the power measuring bridge. Both bridges are balanced in the absence of radio-frequency power. The presence of radio-frequency power causes the power measuring thermistor to unbalance the second bridge, and this unbalance is measured with a vacuum tube voltmeter. The use of the two bridges automatically insures temperature compensation and an output which is linear with power input.

A system for the measurement of fluid pressures in the range from zero to 500 millimeters of water (about zero to one pound per square inch) was described in the paper, "A Miniature Gastro-Manometer for Physiological Use," by H. C. Roberts, University of Illinois, Urbana, Ill. This measuring system was designed primarily for physiological studies, and already has been applied to the measuring and recording of pressures in the stomach (fluid contents) and in the colon (semifluid contents). The pressure pickup, in spite of its small size and weight (1/4 inch in diameter by 3/4 inch long, weight about three grams), is as rugged and stable as its larger predecessors.

The measurement of very short time intervals by commercial cathode-ray oscillographs requires the use of special techniques. Some of these were discussed in a paper called "Short-Time Oscillography," by J. V. Lebacqz (A '40) Johns Hopkins University, Baltimore, Md. The problem arose while the author was working at the Radiation Laboratory at the Massachusetts Institute of Technology. The problem consisted of measuring the time of build-up of the current in pulsed magnetrons, and the fastest linear sweeps available then, provided a time definition of some 2×10^{-8} seconds. In order to ascertain differences in starting behavior of the magnetrons, it was deemed desirable to obtain information on build-up time at least ten times as accurate as was available. In order to solve this problem a type of Lissajou presentation was selected. The transient to be measured is applied to both sets of deflecting plates of the oscilloscope, but the signal applied to one set of plates is delayed a known amount with respect to the other by varying the length of the coaxial cable connecting it to the signal source. The shape of the pattern on the oscilloscope face and the amount of delay introduced permit very accurate determination of the time of build-up of the transient. The paper covered some theoretical considerations on which the work was based, it described the experimental setup used, and some of the results obtained.

Criteria governing the choice of a luminescent screen for cathode-ray oscillography were discussed in "Luminescent Screens

For Cathode-Ray Oscillography," by R. Feldt (M '46) Allen B. Du Mont Laboratories, Inc., Passaic, N. J. The effect of such factors as accelerating potential, beam current, spot size, screen efficiency, writing rate, repetition rate, and decay time were evaluated. Factors subject to external control, such as ambient and incident light, selective color filters, and physiological considerations were discussed. The differences in requirements for general visual oscillography and the visual and photographic study of single transient phenomena were described, and the problems encountered in high- and low-speed moving-film recording were illustrated. A standard method was described for calculating maximum writing rates under given conditions.

An instrument used for both rapid surveys and detailed studies of absorption and emission spectra was discussed in a paper called "High Resolving Power Infrared Recording Spectrometer" by R. C. Nelson and W. R. Wilson of Northwestern University, Evanston, Ill. The development of photoconductive detectors highly sensitive in the region from 0.6 to 3.0 microns has made feasible the design of a grating spectrograph of high resolution for the near infrared. The optical and mechanical design of the instrument was discussed, and an amplifier useful with chopped light and photoconductive cells was described. Applications of the instrument to the study of infrared sources were cited.

A novel measuring device was described in a paper called "The Phase Meter," by E. O. Vandeven, General Electric Company, Schenectady, N. Y. The phase meter is a device used to measure the phase angles of a polyphase voltage source. The principles involved are applicable to frequencies as high as those which oscilloscope amplifiers will handle with a low degree of distortion. The circuit involving these principles was developed at the General Electric Company in connection with the phasitron test program. In this application the phase angles of a 3-phase 230-kc voltage were measured. Essentially each phase voltage is amplified separately, clipped, and differentiated; the pulse outputs therefore being referred in time to the respective phase voltage. These outputs then are mixed and applied to the Z-axis amplifier of an oscilloscope, to the vertical and horizontal amplifiers of which must be applied voltages whose frequency is the same as that of the polyphase supply but separated in phase by 90 degrees. If there is little phase shift and distortion in the amplifiers, a circular trace will appear on the cathode-ray tube. The pulses applied to the Z-axis amplifier are amplified and intensity-modulate the circular trace. If the oscilloscope screen is calibrated radially in degrees the phase angles of the polyphase supply can be read by noting the angular spacing between the leading edges of the modulated portions of the circular trace.

Another paper dealing with problems of phase measurement was "The Accurate Measurement of Relative Phase," by R. A. Glaser of the Massachusetts Institute of Technology, Cambridge, Mass. When it is necessary to determine the phase difference between two otherwise identical signals, a common procedure is to form a Lissajous figure from them on a cathode-ray tube oscilloscope. In general, the resultant pattern is elliptical in shape, and the phase angle can be calculated from measurements of the relative dimensions of the ellipse. In practice the error of measurement usually varies from one to five degrees. The accuracy of this method can be increased greatly through the use of frequency multipliers. In addition, a heterodyne process extends the range of frequencies over which useful measurements can be made. Circuits for producing frequency multiplication were discussed, and attention was devoted to the problem of minimizing phase distortion. Applications were described in which rotary phase shifters can be calibrated with an error not in excess of one minute of angle.

"A Null Method for Determination of Impedance at Frequencies in the 100- to 400-Megacycle Range," by J. F. Byrne, Airborne Instruments Laboratory, Inc., was a paper that discussed the basic theory and described the construction of a measuring system in which the magnitude and phase of an unknown impedance are determined independently. The manipulative procedures are quite similar to those followed in bridge measurements. Typical experimental results were given and compared with impedance measurements using slotted lines.

COAXIAL ELEMENTS AND MICROWAVES

A new type of coaxial attenuator was described in a paper called "A Bead-Supported Coaxial Attenuator for the Frequency Band 4,000–10,000 Megacycles," by J. W. E. Griemsmann (A '39) and H. J. Carlin (A '41) of the Polytechnic Institute of Brooklyn, Brooklyn, N. Y. Special design techniques were described for application to broad-band metalized-film coaxial attenuator inserts operating in the frequency range of 4,000–10,000 megacycles. It was shown that these methods yielded designs having low attenuation and low input reflections over the entire band. Suitable bead supports also are required if the complete attenuator unit is to have broad-band characteristics. Such beads have been developed for this application and their design and operation were described. These developments have led to a new series of fixed-value broad-band coaxial attenuators terminated in type *N* fittings. Experimental characteristics of units with attenuations from 3 to 20 decibels were presented.

"Wave Propagation in Beaded Lines" was a paper presented by R. E. Beam (A '42) of Northwestern University, Evanston, Ill. A transmission line having recurrent discontinuities due to regularly spaced dielectric beads was treated mathematically as a cascade connection of four terminal networks. A section of line equal in length to the distance between successive beads and having a bead at its midpoint is represented by an equivalent T section. Expressions for the characteristic admittance and the hyperbolic sine of the propagation constant in normalized forms were derived. Curves of the normalized characteristic admittance, the attenuation constant, and the phase constant were given as functions of electrical length of the section for certain RMA (Radio Manufacturers Association) coaxial cables. These curves showed that a section of a beaded cable acts as a filter having alternate pass and attenuation bands as the frequency is increased. The higher the order of the pass band, the smaller is its width.

A paper summarizing the development of a new line of coaxial elements and connectors, and the basic techniques anticipated for their use in measurements at high frequencies was "Coaxial Elements and Connectors," by W. R. Thurston, General Radio Company, Cambridge, Mass. The connectors themselves are characterized by the identical form of the two mating parts and by low reflections at frequencies of 300 megacycles to 3,000 megacycles. The coaxial elements associated with these can be assembled in various configurations depending upon the frequency and the type of measurement to be made. The design of these units is such that they are quite suitable for relatively inexpensive equipment.

A paper dealing with the general problem of matching an arbitrary load impedance to a pure resistance by means of a reactive network was "Theoretical Limitations on the Broad-Band Matching of Arbitrary Impedances," by R. M. Fano (A '44) Massachusetts Institute of Technology, Cambridge, Mass. The paper was primarily a systematic study of the original and nature of the theoretical limitations on the tolerance and bandwidth of match and of their dependence on the characteristics of the given load impedance. The necessary and sufficient conditions were derived for the physical realizability of a function of frequency representing the input reflection coefficient of a matching network terminated in a prescribed load impedance. These conditions of physical realizability then were transformed into a set of integral relations involving the logarithm of the magnitude of the reflection coefficient. Such relations are particularly suitable for the study of the limitations on the bandwidth and tolerance of match. Definite expressions for these quantitites were obtained for special cases. The practical problem of approaching the optimum theoretical tolerance by means of a network with a finite number of elements was also considered. Design curves were provided for a particularly simple but very important type of load impedance. In addition, a very convenient method was presented for computing the values of the elements of the resulting matching network.

Broad-band meters were considered in the paper, "Broad-Band Bolometer-Type Ultrahigh-Frequency Power Meters," by M. J. Di Toro (M '45) Polytechnic Institute of Brooklyn, Brooklyn, N. Y. It was pointed out that the design of broad-band meters for the bolometric measurement of ultrahigh-frequency power in a coaxial line involves a compromise between a number of important performance factors.

Outstanding among these factors are bandwidth and sensitivity. Broad-band performance is achieved by the introduction, among other things, of complementary reactive elements which annul the inherent inductive component of a resistive bolometer element. A description was given showing design procedures resulting in a number of broad-band and sensitive meters for the frequency ranges from 20 to 10,000 megacycles and the power ranges from 20 microwatts to 2 watts.

OPERATION OF ELECTRONIC RESEARCH

This rather broad subject was treated in four papers that covered the topic from the point of view of industry, the university, the research institute, and the government agencies.

R. M. Bowie of Sylvania Electric Products, Inc., New York, N. Y., spoke on "Organization and Management of Electronic Research." He cited the principles of organization and operation that have evolved as a result of 10 years of experience in the development and operation of an electronic research organization in industry. He discussed ten cardinal points that are necessary for the proper organization and operation of an electronic research organization. These are good leadership, and espirit de corps, a source of finance, a system of organization and operation, a coordinated system of records, a method for selecting problems, a research sales program, a personnel program, a properly equipped laboratory, and an adequate supporting staff.

"Electronic Research in the University" was covered by L. T. De Vore, of the University of Illinois, Urbana, Ill. He discussed the psychology of research men in order to show how research in universities is built around the ideals of the personnel involved. He discussed incentives for research men in universities listing the quest for knowledge, the desire for recognition, the desire to leave a contribution to knowledge, and the desire for material advantage in the form of patents, and so forth, as being reasons why men undertake research work in universities. Such things as freedom of choice, freedom of disclosure, and freedom of habit also were cited as advantages in doing research work for universities. He pointed out that one of the most serious problems imposed by abnormal postwar conditions was the lack of adequate financing for research in universities. The need for an accelerated program of basic research, ideally suited to university type of work, was pointed out. The high present-day cost of research was indicated as the reason why many universities are looking to the government for aid in financing their research programs.

"Electronics Research Management in Research Institutes" was covered by G. E. Ziegler of the Midwest Research Institute, Kansas City, Mo. He pointed out that three fundamental factors are at the heart of successful electronics research management in research institutes: type of organization, management responsibility, and methods of laboratory operation. Electronics research, where the end product is the solution of industrial problems which may range anywhere from agricultural to manufacturing, requires custom-built electronics research organizations, which may differ greatly from those required for electronics equipment development. The management responsibility of electronics research depends on whether there is sufficient volume of work to warrant having an established department, or whether the electronic work is so dispersed among the other types of research required for the solution of the whole problem that it is best handled under the supervision of the department responsible for achieving the ultimate objective. An analysis of the actual methods of laboratory operation for electronics research discloses that they range from cut-and-try procedure based on experience, to procedures which are mathematically surveyed and analytically planned, but, nevertheless, tempered by experience. Specific examples drawn from the experience of research institutes were cited to illustrate how the various questions which arise in a discussion of the organization, management, and operation of electronics research in research institutes are answered.

GOVERNMENT'S ROLE

The government's role in electronic research was covered in a paper called "Electronic Research and Development," by A. S. Brown, of the Army Air Force Air Materiel Command, Wright Field, Dayton, Ohio. This paper reviews briefly the history of the development of wireless and radio from 1912, when the United States rights to Poulsen arc patents were obtained by Federal Telegraph Company of California, through the succeeding years, including World War I, until the emergency was declared prior to World War II. Some of the early work done in those days, the decision by the Navy to concentrate most of its research work in radio at the Naval Research Laboratory in Washington, and the exceedingly small number of engineers engaged in this type of work until World War II, was commented upon. The next phase of great advancement of the art in radio research occurred during World War II with the rapid expansion of facilities and use of large numbers of scientists, especially those from the universities in government-controlled laboratories. The third phase of government research is the reorganization following World War II in attempting to continue research in what is now termed "electronics" on as large a scale as feasible. The various organizations that have been formed to increase the efficiency per man and per dollar were outlined. The difficulties surrounding government scientists carrying out their work because of necessary government regulations, dependence upon Congress' annual appropriations, and many other factors, were cited. Based on the far-reaching results already obtained, the prediction was made that further and greater accomplishment will be realized if the present progress of combined government, university, and private enterprise is properly co-ordinated and further developed.

The problem of filtering and purifying the first and higher order modes propagating in a wave guide were discussed in a paper called "Higher Mode Techniques for Wave Guides," W. M. Goodhue, Polytechnic Research and Development Company, Brooklyn, N. Y. Devices were described for the elimination of higher modes so that a pure first mode can be transmitted successfully, and, alternatively, devices were described for the transmission of a pure higher mode by rejection of all other modes. Thus it becomes feasible to transmit very high microwave frequencies in a guide size much larger than that commonly used at present. Apparatus has been developed and tested for excitation of pure modes, mode filtering, matching, loading, measurement of field distribution across the guide, and standing wave measurement, all in a large guide without degeneration of the mode. Experimentally, the frequency range in one size of guide has been extended to five times the cutoff frequency, with a likelihood of considerable increase by the same techniques. New and useful concepts have been discovered, permitting a great increase in the number of impedance controls which can be handled easily.

"Multiplex Transmission Through Wave Guides Using Higher Order Modes," was a paper by R. R. Buss (A '40), W. A. Hughes, H. D. Ross, and A. B. Bronwell (M '44) of Northwestern University, Evanston, Ill. The possibility of transmitting two or more signals through a wave guide on the same carrier frequency but using different modes to separate the signals has been investigated both experimentally and theoretically. The paper pointed out that it has been found possible to obtain a relatively high decibel separation between signals when separated on the basis of mode differences alone. Transmission through gradual bends and tapered sections did not introduce serious mode scrambling. An analysis of various types of antenna systems which can be used to set up higher order modes in rectangular and circular guides was also discussed.

An interesting application of microwaves was discussed in a paper called "Microwave Spectroscopy," by D. K. Coles, of the Westinghouse Research Laboratories, East Pittsburgh, Pa. It has been known for over 30 years that very high frequency electromagnetic waves would be absorbed by any gas whose molecules possess electric dipoles. The frequencies at which absorption takes place correspond to the rotational frequencies of the molecule. Measurement of the absorption line frequencies is possible to one part in a million. This gives a proportionally precise measure of the molecular moments of inertia. By studying the fine structure of rotational absorption lines, one obtains information regarding the spins of the atomic nuclei within the molecule and the charge distribution within the nuclei. This paper described different types of apparatus used in microwave spectroscopy, including methods of sweeping the oscillator frequency to present part of the absorption spectrum on the screen of an oscilloscope, and methods

of modulating the absorption lines by means of an electric field applied to the absorbing gas.

"Some Fundamental Considerations Concerning Noise Reduction and Range in Radar Communication" was a paper by S. Goldman, Massachusetts Institute of Technology, Cambridge, Mass. As a preliminary to the discussion of noise reduction, it was shown that the properties of random noise are similar in time and Fourier component domains. This was followed by a detailed analysis of the noise reduction in frequency modulation, pulse width modulation, multichannel signaling, and radar, the analysis of these special cases serving as a background for the general theory to be developed later. There followed a discussion of the distinctions between random noise and signals, of the relations between signals and transmission systems, and of the fundamental significance of selectivity and coherence. A probability measure of noise level then was introduced on the basis of which two general theorems were derived concerning the noise properties of signals. These theorems provide a fairly complete answer to questions of range and noise reduction in radar, and give the beginning of the answer in the case of communications systems. It was shown that maximum range in communication is essentially independent of the type of modulation used, for a given total energy. It also was shown how extra bandwidth can be used for purposes of noise reduction and a detailed analysis of the mechanism and possibilities of noise reduction was given.

JOINT NEC AND AIEE SESSION

Four papers were presented at the joint National Electronics Conference and AIEE session, which was presided over by C. H. Willis (F '42) chairman, AIEE technical committee on electronics, Princeton University, N. J.

A new position detector was described in a paper called "The Position Convectron, a New Type of Dynamic Vertical Sensitive Element," by M. A. Babb (A '31) Eclipse Pioneer Division, Bendix Aviation Corporation, Teterboro, N. J. The position Convectron is a new type of dynamic vertical sensitive element capable of giving a useful controlling electric signal with only one minute arc change from its null position. The shifting of its null position is reduced to a minute or two (because of ten per cent voltage deviation, changes in ambient temperatures, and magnetic fields) by potting it with compound in a small magnetic shielding box placed in an outer thermal shielding box with a thermostatically-controlled heater. There is a position of the Convectron which, when balanced to null by a potentiometer, will give the least change in null position for supply voltage variations. Such a unit will cause a 2-volt output from the discriminator part of an electronic circuit with a time lag of approximately one-tenth of a second due to a one minute arc change. The unit operates because the resistance of a fine wire heated by an electric current changes with the angle of the wire to the vertical due to the temperature coefficient of the wire and the convection cooling of the gas surrounding the wire. The wire used is 0.0005-inch diameter nickel and is surrounded by argon gas in a glass tube.

"A New Line of Thyratrons," was a paper presented by A. W. Coolidge, (A '42) of General Electric Company, Schenectady, N. Y. This paper describes a line of thyratrons that has been developed to satisfy the increasingly stringent tube requirements imposed by the industrial control field. The new demands embody quick heating, high peak-to-average current ratio, wide ambient temperature range, high surge current rating, dual grid control, compactness, ruggedness and reliability. A novel method of tube construction proved to be an effective approach to the design of this line, from the standpoint of meeting the technical requirements and also permitting low cost assembly. The construction is such that the tube may be loaded to a high gas pressure, an important factor in assuring long life in circuits having inductive loads. Ratings and characteristic curves were given for the 6.4- and 3.2-ampere gas-filled tubes and the 6.4- and 3.2-ampere gas and mercury-filled tubes. Results of operation tests with inductive loads also were given.

The other two papers of this joint session, "The Glass-Enclosed Reed Relay" by W. B. Ellwood, Bell Telephone Laboratories, New York, N. Y., and "Capillary-Fed Mercury Contact Relay" by J. T. L. Brown (A '21) and C. E. Pollard, Bell Telephone Laboratories, New York, N. Y., have appeared in *ELECTRICAL ENGINEERING* (*EE, Nov '47, pp 1104-09*).

COMPUTERS

Problems of digital computers of the EDVAC and newer types were discussed in a paper called "Electronic Computers" by J. W. Mauchly and J. P. Eckert, Jr., Electronic Control Company, Detroit, Mich. Some solutions to the difficulties of computer design were suggested and the actual designs used were given, including circuit diagrams and the descriptions of the various parts of the computer.

"Storage of Numbers on Magnetic Tape" was discussed by J. M. Coombs (A '41) Engineering Research Associates, Inc., St. Paul, Minn. This paper describes a memory system for storing digital information on magnetic tapes. The tapes are bonded to the surface of an aluminum drum. Associated with each tape are three heads for reading, writing, and erasing magnetized spots on the tapes. This equipment allows numbers to be stored indefinitely, to be inspected as often as required, and to be removed when no longer needed. The system will store 200,000 magnetized spots on a drum 34 inches in diameter and 10 inches wide.

A specialized application of computers was discussed in a paper called "Computers for Aeronautical Navigation," by O. H. Schuck (M '41) Minneapolis-Honeywell Regulator Company, Minneapolis, Minn. The need for improved means of en route navigation, integrated into a coherent system for traffic handling, was pointed out in this paper. Impracticability of providing separate guidance beam systems for all required air lanes leads to necessity for navigation computers to use data from a few radio stations located in positions selected for convenience in siting. Computer design details depend upon operating requirements and nature of radio data to be used. The computers were classified as graphical or analytical. Mechanical and electrical methods of performing analytical computation processes were reviewed. Based on assumed requirements for en route navigation along any assigned one of a number of parallel tracks, examples were given of possible graphical and analytical computers for the four basic types of radio data. These include one bearing–one distance, two bearings, two distances, and two distances differences. The analytical types are peculiarly adaptable to scheduled traffic control procedures and to automatic flight control.

ELECTRONIC CIRCUIT ANALYSIS

Seven papers on electronic circuit analysis were presented in two sessions of three and four papers respectively.

A special innovation of cathode follower circuits was discussed, in the paper, "Some Considerations Concerning Cathode-Tapped Cathode Followers," by B. B. Underhill (A '46) Pennsylvania State College, Pa. For certain applications of the cathode follower it is advisable to return the grid to a tap on the cathode resistor rather than to ground. It was pointed out that when this is done the output admittance of the cathode follower no longer may be approximated by the transconductance of the tube but must include terms involving the impedance of the source to which the cathode follower is connected, the tube parameters, and the fraction of the cathode resistance included in the grid return circuit. Graphs were included which illustrated the effect of variations of the cathode tap on the input admittance, the output admittance, the stability of the circuit, and circuit gain. The approach was analytic involving certain qualifying assumptions which are usually met in practice.

"Low-Power Frequency Multipliers" was presented by R. J. Schwarz (A '44) Columbia University, New York, N. Y. Frequency multipliers of the tuned-circuit type using pentodes were analyzed to give expressions for the output voltage in terms of the signal voltage, load impedance, order of the desired harmonic, and constants depending on the tube characteristics. Non-dimensional curves were presented showing the variation of a quantity proportional to output voltage with a quantity proportional to signal voltage for various multiplication factors, based on linear and square law tube characteristics. Circuits with separate and self-bias were considered and a method was given to correct for the effect of grid-current flow. Experimental results were compared with those predicted by theory and were found to be in agreement.

"Series Mode Quartz Crystal Oscillator Circuit" by H. Goldberg (M '44) and E. L. Crosby, Jr., Bendix Radio Division of Bendix Aviation Corporation, Baltimore, Md., described a series mode crystal oscil-

lator circuit which has particular application in the frequency ranges from 10 to 300 megacycles. The circuit is particularly useful for so-called "harmonic operation" of quartz crystals. Direct operation of crystals at 11 times their nominal frequency is achieved easily. Crystals with nominal frequencies of ten megacycles have been operated directly at 110 megacycles. If desired, electrical harmonics of the oscillation frequency may be obtained from the same circuit. Thus, frequencies of the order of 250 megacycles may be obtained from a single twin-triode circuit with crystal stability. The stability of the circuit with respect to tube parameters is better than for conventional circuits even at the nominal crystal frequency, and very much better for harmonic operation. With slight modification, the same circuit may be made to operate as a converter for superheterodyne reception, operation at 250 megacycles with crystal control using only a single tube being possible. Another modification which uses two tubes provides a crystal-controlled power oscillator which may be plate-modulated and which may be operated at a multiple of the nominal crystal frequency. 400 watts output has been obtained with a 2-tube circuit operating at 25 megacycles with crystal currents well below the danger point.

"Semigraphical Analysis of Oscillator Frequency Instability" by F. P. Fischer, University of Connecticut, Storrs, Conn. A method is described which quantitatively, as well as pictorially, evaluates the effect on oscillator frequency of known changes of interelectrode tube capacitances, dynamic plate resistance, transit-time angle of the transconductance, tank circuit resistance, and losses suffered between grid and cathode of the tube. The method of attack is as follows: the equivalent circuit of the tube and associated circuit exclusive of the tank circuit is computed by usual methods which results in a series capacitor and negative resistor. These may be converted to a parallel negative resistor and parallel capacitor. If such elements are connected to the tank circuit, frequency equilibrium is established when the net a-c watts and vars reduce to zero. This means that any two portions of the equivalent circuit formed by an arbitrary line of demarcation must be in a state of conjugate impedance match or conjugate admittance match. If one parameter is varied at a time and if the frequency shifts are small as experienced in spurious instability, a circular locus prevails (straight lines being special cases) for all complex impedances and admittances that can vary as a result of the original parameter change. If joint parameter variation is desired, the resultant effect can be observed by noting families of circles. Consequently the relative effect of diverse circuit changes can be noted by graphical means, and adjustments necessary to reach a certain goal are indicated in a pictorial manner. The oscillator performance can be executed in an analytic manner also. In particular, the effect of transit-time angle on frequency stability can be computed, and for the first time, one can analyze easily transit-time modulation as a consequence of plate voltage instability. The effect of plate voltage on frequency by virtue of changes in plate resistance are also recognizable. Frequency shifts due to filament heating variations manifest themselves through changes of "hot" interelectrode capacitances (space charge changes and geometrical changes) and can be evaluated. The part played by grid losses and suppression of same by pentodes with Miller effect translated through the screen grid is apparent. Finally, one can judge the properties of a tube that will cause the least frequency instability in a certain circuit as well as the appropriate loading that can be tolerated for a given per cent of frequency instability.

"The Transient Behavior of Nonlinear Systems" was presented by C. S. Roys (M '45) Syracuse University, Syracuse, N. Y. This was an extension of the series expansion for the plate current of a vacuum tube under steady-state a-c conditions, to the transient analysis of nonlinear systems. Application was made to a typical rectifier circuit resulting in calculated oscillograms of charging current and condenser voltage.

A paper that presented the results of a critical study of the relative merits of certain powerful mathematical methods that yield approximate solutions satisfactory for actual design was "A Critical Study of Variational and Finite-Difference Methods for Calculating the Operating Characteristics of Wave Guides and Other Electromagnetic Devices," by R. M. Soria (A '43) and T. J. Higgins (A '40) Illinois Institute of Technology, Chicago, Ill. Exact analytical solution of the characteristic values of the electromagnetic fields associated with a wave guide, horn, cavity resonator, or other bounded hollow electromagnetic device can be effected only for a certain limited range of geometry. Much of the apparatus in present or projected use is not of this geometry, hence does not lend itself to an exact analytical treatment. The powerful methods that yield approximate solutions whose relative merits were studied are the variational procedures deriving from the work of Rayleigh and Ritz, Galerkin, Grammel, Weinstein, Temple, Trefftz, and Newing; the finite-difference procedures resulting from the researches of Liebman, Collatz, and Southwell. These results are obtained by application of each of these methods to the calculation of the characteristic values and electromagnetic fields of both *TM* and *TE* modes in wave guides of various cross-sections.

"An Analysis of the Behavior of a Limiter-Discriminator Frequency-Modulation Detector in the Presence of Impulse Noise" was presented by J. C. Tellier, Philco Corporation, Philadelphia, Pa. It was pointed out that in the presence of high-level impulse noise the performance of a limiter-discriminator circuit has been found to differ from that of an ideal frequency modulation detector, as conventionally defined. Experimental data were presented showing the nature and extent of the differences, together with a theory of behavior of such a detector under conditions of impulse noise.

NEW DEVELOPMENTS IN ELECTRONICS

Because of the relatively slow velocity of propagation of sound waves compared to radio waves, echo-ranging techniques using sound waves readily are adapted for use in guidance devices for the blind. Such an application was described in the paper, "Ultrasonic Guidance Devices for the Blind," by F. H. Slaymaker and W. F. Meeker, Stromberg-Carlson Company, Rochester, N. Y. Frequency modulation and pulse types of ultrasonic echo-ranging systems were described and demonstrated. Fundamental properties of waves such as specular reflection, diffraction around corners, scattering from small objects, interference, and the Doppler effect, were demonstrated, and the relation of these properties to the performance of the guidance devices were discussed. Some natural noises existing in the ultrasonic region were also shown. A portable unit that could be used by a blind person was exhibited, and it was pointed out that the device is in the developmental stage at the present time.

Preservation of solid as well as liquid foodstuffs by means of penetrating electrons was described in a paper called "Heatless Preservation with Penetrating Electrons from the Capacitron," by W. Huber and A. Brasch, Electronized Chemicals Corporation, New York, N. Y. Deleterious effects to taste, odor, or appearance have been avoided by the application of high intensities in ultrashort periods of time of the order of 10^{-6} seconds and less. The penetrating electrons of ultrashort time duration were obtained by the condenser-impulse method as utilized in the Capacitron. The latter is a combination of surge generator and laminated discharge tube which releases broad beams of highly accelerated electrons in discontinuous surges. The impulse time can be varied between 10^{-6} and 10^{-9} seconds. The development, past and present, as well as the working principles of the Capacitron were briefly discussed. Charts showing the results of tests using the Capacitron for heatless preservation of foodstuffs and sensitive drugs were also shown. Although in principle all types of edibles can be subjected to this "cold" energy in order to inactivate micro-organisms and enzymes, the case of preservation without undesirable changes varies in rather wide limits. It is immaterial if the food to be preserved is raw or precooked to any degree since the state in which it is subjected to the Capacitron is generally well maintained.

The Federal Communications Commission has assigned a band of frequencies extending from 460 to 470 megacycles for use as a Citizen's Radio Service. Regulations covering technical performance and licensing procedures have been written so as to encourage application of ultrahigh-frequency communication to the needs of the general public. The paper reviewing the Federal Communications Commission's rules and regulations was

"Engineering Aspects of the Citizen's Radio Service" by R. E. Samuelson of The Hallicrafters Company, Chicago, Ill. Advantages and limitations of low-powered ultrahigh-frequency radio systems, as well as a number of suggested applications, were presented. The propagation characteristics at frequencies of the order of 465 megacycles were reviewed with emphasis on the performance to be expected from a given complete system of two stations taking into account equipment, antennas, and intervening terrain. One simplified method of roughly predicting this performance in terms of maximum useful distance of communication was presented. Experimental models of 465 megacycle equipment and a discussion of the engineering problems involved were presented. Typical performance figures obtained in the laboratory were given, together with a description of measuring techniques found useful.

"German Military Applications of Infrared" by E. A. Underhill, Air Materiel Command, Wright Field, Dayton, Ohio. It was pointed out that during the early months of the submarine warfare, the Germans assumed that the Allies were using infrared to detect their submarines. They organized what was known as the Infrared Working Committee to expedite research on infrared detectors as countermeasures, and to develop infrared devices for the control of guided missiles. Two of the most important developments as a result of that research were an improved image converter tube and the lead sulphite cell. Applications of these developments resulted in some very effective offensive weapons as well as early warning devices. Large telescopes, employing the "Bildwandler" (German image converter) were developed, that were capable of detecting aircraft at distances up to 20 miles from the heat radiation of the exhaust stubs of the planes. Telescopes were designed and used on tanks and antitank guns as night sighting equipment. Night driving was made possible by the use of infrared headlights and telescopes. The lead sulphide semiconductor made possible better jam-proof communication equipment and the possibility of interception was at a minimum. The cell also was used effectively as a heater seeker for guided missiles launched against such heated targets as ships, blast furnaces, or locomotives.

INDUSTRIAL ELECTRONICS

"Some New Cathode-Ray Oscillographs and Their Applications" was presented by C. Berkley, of the Allen B. Du Mont Laboratories, Passaic, N. J. Five instruments which are or shortly will be available commercially were described. Among these was a polar co-ordinate indicator developed for studies in connection with rotating mechanical systems; a high-voltage cathode-ray oscillograph indicator and its power supply, capable of operation up to 29 kv for use in high-speed transient studies; a precision cathode-ray oscillograph developed for television waveform monitoring, capable of driven sweeps of two-inches-per-microsecond writing speed and having a bandwidth of 10 megacycles; a standard high-voltage oscillograph and power supply for use in high-speed photography and projection of patterns for educational purposes; and a dual-beam oscillograph with completely independent control of both beams. Accessories to these instruments for calibration, projection, and photographic recording were described. Design features of these cathode-ray oscillographs indicating future trends also were discussed, and typical applications were described and were demonstrated during the presentation.

An electric servo system which measures, controls, and records the load applied to a specimen in a lever-type fatigue testing machine, was covered in the paper, "High Capacity Servo System for Control of a Mechanical Testing Machine," by H. W. Katz and H. C. Roberts, University of Illinois, Urbana, Ill. The servo system consists of a resistance strain-gauge Wheatstone bridge, a conventional amplifier, and a phase sensitive detector whose output controls a 3-phase motor. The amplifier and its associated control circuit are applicable to other types of testing machines.

"Sealed Ignitrons for Radio Transmitter Power Supplies" were discussed by H. E. Zuvers (A '43) General Electric Company, Schenectady, N. Y. Sealed ignitrons for rectifier service are being developed and applied to the task of supplying all types of d-c power to industry. The latest development is the *GL-5630*, a tetrode ignitron developed for use in radio transmitter power supplies. This sealed ignitron is rated at 20,000 volts and 50 amperes. Six of these tubes in a bridge circuit will supply up to 3,000 kw of d-c power. This will be more than ample for any projected installation. This tube is a smaller version of the d-c transmission type *GL-506* used in the 10,000-kw electronic frequency changers at the Carnegie Illinois Steel Corporation. A power supply using these high voltage ignitrons offers the following advantages: no heating time required, output voltage control by varying angle of firing, longer life—up to 3 plus years may be expected, and finally, the rectifiers can be used as extremely fast circuit breakers. Whenever a gas flash occurs in the transmitter the rectifier blocks—no new tube starts conduction—so there is no more power fed into the short circuit from the a-c circuit. The *GL-5630* has two grids. One is used as the control grid to time accurately the starting of current flow. The other grid is a potential dividing grid between anode and cathode and makes possible the use of a mercury tube at 20,000 volts.

A method of analyzing a type of circuit where the current and voltage wave forms are usually discontinuous functions of time was described in a paper called "Analysis of Single-Phase Grid-Controlled Rectifier and Inverter Circuits," by C. M. Wallis (M '41) University of Missouri, Columbia, Mo. The rectifier input-transformer impedance was neglected and the tube drops were assumed constant. General formulas, expressing the currents and voltages prevailing in such circuits as time functions were derived by operational means. From these general equations, the wave forms were deduced for inductive and capacitive loads on the d-c side when the load current was either continuous or noncontinuous. In the case of inductive loads, the criterion for noncutoff operation was formulated which allows one to determine whether or not there is a continuous load current flow for a given set of circuit constants and grid-control angle. The operation of the tube circuit as a connecting link between an active single-phase a-c system and a d-c system to allow power flow in either direction was analyzed. Several numerical examples were included to illustrate the use of the general equations.

ANTENNAS

"High Gain with Discone Antennas" by A. G. Kandoian (M '46), W. Sichak, and R. A. Felsenheld, International Telephone and Telegraph Corporation, New York, N. Y., was a paper describing extension of work on Discone-type antenna originally presented before the Institute of Radio Engineers in 1945. Since that time, Discone-type antennas have been developed for a large number of applications. Of particular interest are those applications which require high gain over a very broad band of frequencies. Detailed data were given on several designs, particularly on unidirectional antennas useful for point-to-point communication and omnidirectional high-gain antennas such as are used in the aerial navigation field.

"Slot Antennas" were described by N. E. Lindenblad, Radio Corporation of America, Camden, N. J. The development of flush-type radiators of the slot and pocket type were described. Special emphasis is made of types applicable to aircraft. Specific solutions to altimeter and marker beacon pickup antennas were described, and reference to application in other fields also was made. The general aspects of the phenomena which are involved were examined and it became evident that workable solutions, in the majority of cases, can be obtained only by means of actual experience since variations in the surroundings have first order influence upon such vital characteristics as radiation patterns, slot impedance, and bandwidth. Progress before and during the war was described in a somewhat chronological manner. It was pointed out that while this progress has been considerable, an appreciable amount of skillful investigation remains to be done before slot antennas can be brought to maximum usefulness.

The paper, "The Patterns of Multiple Slot Cylinder Antennas," by G. Sinclair of the University of Toronto, Toronto, Ontario, Canada, indicated that it is possible to calculate the horizontal patterns of vertical slotted-cylinder antennas. Patterns have been calculated for single slots in cylinders having diameters up to one-half wave length. The calculated patterns check well with actual measure-

ments. The possibilities of using multiple-slots in a cylinder then were considered and the patterns calculated for a number of simple arrays. It was found that the use of multiple slots permits the control of the horizontal pattern of slotted-cylinder antennas for frequency modulation, television, and other applications.

An air-to-ground system which is capable of plotting automatically the absolute pattern of both the horizontally and vertically polarized radiation from an aircraft in flight, was described in the paper, "Systems for Measurement of Very-High-Frequency Aircraft Antenna Patterns in Flight," by J. S. Prichard (A '39) and A. H. Mankin, Airborne Instruments Laboratory, Inc., East Hempstead, N. Y. An automatic tracking radar system is used to provide position information and to orient the directive receiving antenna. During measurements the aircraft describes level-flight straight-line paths, making possible the recording of the patterns in the plane described by the flight path and the ground receiving position. The limitations and errors of the system were discussed.

"Factors Affecting Choice of Transmission Frequencies for Line-of-Sight Systems" were considered by L. S. Schwartz (A '45) Hazeltine Electronics Corporation, New York, N. Y. An attempt was made to analyze the factors involved in the choice of transmission frequencies for line-of-sight systems. As these are manifold, one system with diverse characteristics and broad applicability—the interrogator-beacon—was selected for study. It was hoped that the results of this study might serve as a guide in whole or in part in the selection of operating frequencies for a number of other systems. The procedure adopted was to study the spectrum of electromagnetic frequencies for which the characteristics of the propagation path, the antenna pattern, and the receiver sensitivity are such as to optimize the fundamental criteria of good interrogator-beacon design: reliability, traffic capacity, coverage, and so forth.

NUCLEONICS

A vacuum leak detector which offers definite advantages in simplicity and economy of construction over the conventional type was described in the paper, "A Mass-Spectrometer-Type Leak Detector Utilizing a Cold Cathode Ion Source," by R. F. Wall, H. Sommer, and H. A. Thomas (A '40) Agricultural and Mechanical College of Texas, College Station, Texas. These advantages are obtained by the use of a cold cathode ion source. The only operating adjustments required are the regulation of the source pressure and occasional rezeroing of the meter. The standard leak serves for checking instrument response and electrical line-up.

"The Photomultiplier Radiation Detector" by J. W. Coltman and Fitz-Hugh Marshall, Westinghouse Research Laboratories, East Pittsburgh, Pa. This detector consists of a multiplier photoelectric tube efficiently arranged to register scintillations produced in a fluorescent screen by individual quanta of X rays or nuclear radiations. Though efficient only for narrow beams of radiation, this device is capable of a much higher counting rate than a Geiger counter. It has a higher measured efficiency for those radiations tested, and has negligible window thickness. The ultimate sensitivity of the detector is limited by noise from electrons emitted thermally from the photocathode. Though signal pulses are generally higher than noise pulses, complete discrimination is not possible because of wide variations in output pulse amplitude arising from statistical variation in gain per stage in the nine stages of secondary emission amplification within the multiplier tube. The highest noise pulses tend to overlap the lowest signal pulses. Signal-to-noise ratios have been improved greatly by selection of tubes, by use of an efficient fluorescent screen, and by careful design of the optical light-gathering system. Discrimination between the short noise pulses and longer signal pulses is furthered by setting the time constants of the input and output circuits of a following amplifier equal to the 20-microsecond decay constant of the fluorescent screen.

"Precision Studies of Nuclear Physics Using the Electrostatic Generator" by W. E. Shoupp of the Westinghouse Electric Corporation. The advantages and limitations of the various nuclear accelerators are not generally realized. Experiments particularly adaptable to solution by the use of the electrostatic generator were discussed. In particular, methods were given for the determination of mass values from threshold determinations of nuclear reactions, the production of variable energy neutron beams, the determination of the maximum of beta-ray spectra, and other experiments. A radio-frequency ion speed gauge that is adaptable to the measurement of the beam velocities of nuclear accelerators was described. This offers a new method of calibration of the nuclear absolute voltage scale.

MILITARY APPLICATIONS OF ELECTRONICS

"The Role of Electronics in Guided Missile Research" was covered in a paper by W. N. Brown, Jr., of Haller, Raymond, and Brown. Many of the guided missiles used during World War II were conceived and developed by specialists in the design of aircraft or bombs. Desirable electronic features often were omitted entirely or were not sufficiently integrated with the design of the missile and guidance system. Expressed simply, the guided missile problem is to get the missile within lethal range of the target and to detonate the missile. In order to do this it is necessary to provide means for locating, identifying, and continually monitoring the behavior of the target, to launch the missile in an optimum way, to guide the missile along a continually recomputed collision course, and then to detonate the missile at the most opportune time. Technological limitations make this an exceedingly difficult problem that can be solved only by painstaking compromise among the various components of the guided missile system and by designing the missile system around known characteristics of the intended target. Active planning and direction of individual programs now is being carried out in the United States by scientists qualified to cope with the diverse problems encountered and the various branches of technology now are being well integrated at the planning level. Consequently, work in the guided missile development program now offers electronics engineers unparalleled opportunities for broad and stimulating experience.

A telemetry set designed specifically for guided missiles was discussed in the paper, "Telemetry System for Guided Missiles," by L. J. Neelands and W. Hausz of the General Electric Company, Schenectady, N. Y. The emphasis in this system is on simplicity, light weight, compactness, large numbers of channels, high accuracy, and expendability. A mechanical commutator samples each of 28 channels, 35 times per second, transforms the information to pulse width and transmits it to the ground station where display on cathode-ray tubes permits photographic recording on 35-millimeter film.

"Electronics Development in Germany During World War II" by A. H. Sullivan, Jr. (A '40) Air Materiel Command, Wright Field, Dayton, Ohio, was not presented because the author had not returned from Germany. However, some of the points in Mr. Sullivan's paper were covered by B. L. Griffing, also of the Air Materiel Command, who combined his own paper and Mr. Sullivan's into one talk. The material from the two papers is reviewed here separately. During World War II, the Germans made extensive investigations in all fields of electronics, physics, and other associated scientific fields, in order to improve the efficiency of the war machine in every possible way. Of particular importance was their work in guided missile control methods, infrared techniques, and radio navigation devices. In addition, there were many special developments in cathode-ray tubes, magnetrons, klystrons, storage tubes, and antenna systems. Developments also were made in recording systems, equipment components, ceramics, and test equipment. Not only were the technical phases of the various devices thoroughly investigated, but the physiological and psychological effects of operation, as well as the number of man hours needed for maintenance, also were studied. The general results of the systematic and thorough work of the German technicians and scientists appeared in improved electronic equipment of all types, some of which have not yet been duplicated in the United States. From a military point of view, it is highly desirable that the German techniques be incorporated in electronic equipment produced in the United States.

GERMAN DEVELOPMENTS

"German Microwave and Component Developments" by B. L. Griffing, Air Materiel Command, Wright Field, Dayton,

Ohio, covered other German scientific developments. In two years time, spurred by an intensive program of research, the Germans succeeded in covering most of the microwave region from ten centimeters to three millimeters with some kind of a tube. Among these are magnetrons of the interdigited type; tunable klystrons covering bands from one to five centimeters, with nearly 2-to-1 tuning ratio; and velocity-modulated tubes using one cavity only, the bunching takes place in the presence of the electromagnetic field. The metal ceramic tubes developed by Telefunken Company in Germany have become an important item of development in the United States. Companies now are adopting this technique rapidly, and soon these ceramic seals will be available for experimental laboratories. Another notable achievement has been in the development of a focusing cathode by Doctor Heil. Some of his latest experiments with these cathodes give a concentration of electrons of 200 to 1, when the area of the cathode is compared to the area of the beam. The image storage tube is a unique German development, in which an image can be retained in the form of electric charges on a mosaic screen for as long as three weeks, at any time during this period the image can be viewed by illuminating the mosaic and focusing the photoelectrons on a fluorescent screen.

COMMUNICATIONS

"Teleran—A Technical Progress Report" was a paper by R. W. K. Smith, D. H. Ewing, and H. J. Schrader, Radio Corporation of America, Camden, N. J. Following a brief description of teleran, a pictorial air navigation and traffic control system, some of the problems were set forth which had to be overcome before the equipment could be built. The discussion included the storage orthicon camera and its use for improving radar information. The daylight viewing cockpit kinescope and special circuits were covered and the paper concluded with the results of flight tests to date.

"Crystal Saver Circuits for Very-High-Frequency Receivers" were discussed by W. R. Hedeman, Jr., of Bendix Radio Division of Bendix Aviation Corporation, Baltimore, Md. Presently allocated channels in the band from 108–118 megacycles for aircraft navigation by means of the CAA (Civil Aeronautics Authority) omnidirectional range, and the localizers, have raised new receiver problems. Transmitters located approximately 125 miles apart will be used. Aircraft on long flights will require crystal-controlled reception on 20 or more channels. The operational aspects of the problem require that the aircraft receiver be capable of instantaneous tuning to any one of the frequencies which might be used, or 50 channels. Additional communications facilities in the 118–132-megacycle band, and an imminent decrease in channel spacing raise the requirements to 280 channels. Several different circuits for obtaining this number of crystal-controlled channels with but a few crystals, were presented.

"Pulse Count Modulation (PCM)" was a paper by D. D. Grieg (A '39) and S. Metzger, International Telephone and Telegraph Corporation, New York, N. Y. A principal characteristic of pulse modulation systems is the time sampling of the intelligence wave to be transmitted. Examples of such systems have been described in the literature and include pulse amplitude modulation, pulse width modulation, pulse time modulation, and pulse frequency modulation. In addition to sampling in time, it is also possible to sample in amplitude in such a manner that only discrete levels are transmitted concurrently with time sampling. A system utilizing the simultaneous time sampling and quantizing of amplitude is a pulse count modulation system. Many advantages are gained by utilizing such a system, including the possibility of transmission of the voice signals by means of a code similar to the automatic printing telegraph signal. Other advantages include a large signal-to-noise improvement ratio, and minimization of cross talk under conditions of large pulse carry-over, as well as the many other advantages of the more conventional systems. Some of the fundamental properties of a pulse count modulation system were cited including the relationship between distortion and the number of quantization levels.

"The Application of Existing Techniques to the Problem of Air Traffic Control" was discussed by W. D. White of Airborne Instruments Laboratory, Inc., E. Hempstead, N. Y. The results and conclusions of a study made for the air navigation and traffic control division of the Air Transport Association were given. The principal objective has been a study of possible means of implementing a system of air traffic control using known techniques. It is believed that if any significant improvement is to be made in the reliability and regularity of air transport service at the more congested centers during the next several years, such improvements will have to be obtained by the intelligent utilization of existing equipment and techniques. The objective in formulating the proposal contained in the paper has been to evolve a system built around the omnidirectional range and distance-measuring equipment which is capable of providing some benefit in the interim period and which is also capable of step-by-step expansion to meet the changing operational requirements as the state of the electronic art evolves.

INDUSTRIAL APPLICATIONS

"Fluorescent Lamp Operation at Frequencies Above 60 Cycles," by J. H. Campbell and B. D. Bedford (M '43) General Electric Company, Schenectady, N. Y., was presented by J. H. Campbell. This paper was concerned with a study of the characteristics of the fluorescent lamp and accessories over the frequency range from 60 to 2,500 cycles. This study was made with the objective of determining if smaller, lighter weight, and lower cost accessories could be used for fluorescent lamp operation. It was found that the efficiency of the lamp was higher at the higher frequencies and that the ballast could be so simplified that a capacitor could be substituted economically for the inductance. Methods of generating the higher frequencies were investigated also and B. D. Bedford (M '43) discussed a harmonic generator for 540 cycles from a 3-phase 60-cycle power supply. The unit described employed a nonlinear inductance that caused the generation of harmonics which produced the 540-cycle d-c power. The unit was small and its efficiency was slightly greater than 70 per cent.

An unusual torquemeter was discussed in the paper, "A Magnetostriction Torquemeter," by C. M. Rifenbergh, D. S. Schover, and E. H. Schulz (M '43) of Armour Research Foundation, Chicago, Ill. The instrument is unique in that no mechanism must be mounted directly on the shaft. The size and the weight of the pickup are such that the instrument may be applied in many places where no other torquemeter is applicable. The principle of operation is as follows: two magnetic circuits, with their magnetic fields operating along opposite 45 degree helices on the shaft in which torque is to be measured, form two arms of a bridge circuit. Under torque, the field of one coil acts along a compression line on the shaft while the other operates along a tension line. Magnetostrictive effects result in an unbalance of the bridge and the unbalance voltage is directly proportional to torque. A suitable amplifier and direct-reading instrument form the auxiliaries for the instrument.

SATURABLE CORE MAGNETOMETER

"Applications of the Saturable Core Magnetometer" was presented by W. E. Tolles, Airborne Instruments Laboratory, Inc., E. Hempstead, N. Y. This paper discussed the high degree of versatility and breadth of application of the saturable core magnetometer. This versatility depends on the wide available range of the magnetometer's basic electrical and physical characteristics, such as sensitivity, linear response, frequency response, and physical size of the detecting element. Several basic forms of the saturable core magnetometer were discussed. These included: single magnetometer unit of high or low sensitivity for the measurement of the magnetic field in an arbitrary fixed direction, narrow- or wide-base gradiometer composed of a pair of magnetometer units, a self-stabilized magnetometer for the measurement of the magnitude of the total magnetic field, and combination of self-stabilized magnetometers for measuring the gradient. Each of these main forms suggested a number of specific applications to laboratory and field problems of magnetic measurements.

"Thyratron Control of A-C Commutator Motors" was discussed by W. N. Tuttle, General Radio Company, Cambridge, Mass. A thyratron-shunted transformer in series with an a-c commutator motor permits automatic control of applied alternating voltage to maintain preset

speed under varying load over a wide range of speeds. This system offers advantages of simplicity and low tube cost, but requires a tachometer generator for control of the thyratrons. Plugging and instant reversal can be provided for economically within the continuous duty rating of the tubes. Performance characteristics were given for a 1/2-horsepower 4-pole repulsion motor operating over a speed range of 100 to 1,750 revolutions per minute.

BASIC SCIENCE

"Electrical Semiconductors" were discussed by K. Lark-Horovitz of Purdue University, Lafayette, Ind. Though the electrical resistance of metals increases with increasing temperature, a number of substances known as semiconductors show high resistivity at low temperature, their resistance decreases as the temperature is raised, reaches a certain minimum, increases again and finally decreases another time and much more sharply when a higher temperature is reached. This behavior can be explained completely on the assumption that the number of electrons in these substances is dependent on temperature. It is assumed that, at low temperatures, the number of electrons is small. As the temperature increases, a greater number of electrons becomes free, dissociated from so-called electron "donators." When all of these electrons are finally free, the collision of these electrons with the atoms present in the lattice of the semiconductor decreases the conductivity and as a consequence the resistance again increases.

There is, however, the possibility that more electrons might be freed at higher temperatures which are coming from the semiconductor itself and not from the donators. These so-called intrinsic electrons are far greater in number than the number of electrons which are freed from donators, and as a consequence, the resistance at higher temperature decreases very rapidly. It is possible that instead of donators in the semiconductor, "acceptors" might be found. These impurities have the property of not giving off electrons at higher temperature, but taking on electrons. Consequently there remains in the body of the semiconductor a "hole" in the electron distribution. This hole has all the properties of a "positive" electron and an effective mass which is different, usually larger, than the mass of the ordinary electron. Thus it is possible to create a conductor of electricity which might conduct by particles which in every respect behave as free electrons do, except their effective mass is different from the mass of the ordinary electron, and their charge is just opposite. Semiconductors have a great many uses. The fact that electrical resistance drops with increasing temperatures makes them extremely useful for certain current limiting devices with so-called thermistors. These find a wide use in all telephone services. They are installed at frequent intervals in all our transcontinental telephone lines. If a semiconductor and a metal are brought into contact, there develops at the boundary between the metal and the contact, a "barrier layer," across which electrons can pass in one direction, but not in the other; thus a rectifying action is produced.

Regardless of the type of semiconductor, whether it conducts by negative electrons or by something which behaves like a positive electron, in such a contact, the carriers flow from the semiconductor to the metal in the forward direction. Thus it is possible to have two types of rectifiers, the ones which are based on the ordinary electronic conductors and which are called *N*-type rectifiers, and the others which are based on a hole conductor which are called *P*-type. The rectification is opposite in the two cases. It has been possible to make germanium alloys which are excellent rectifiers for ultrahigh frequencies or microwaves in a region where the ordinary tube is difficult to use as a rectifier. There also have been made the so-called high back-voltage rectifier. Only certain impurities will give the microwaves rectifier and only certain other impurities will give the high back voltage rectifier. There is also the possibility to produce a change in the number of electrons, not only by a change of temperature, but by having light fall on the semiconductor. The behavior of semiconductors at extremely low temperatures now is being carried on and opens the possibility for a better understanding of the metallic state and the electrical conductivity of matter.

THE CESIUM ARC

"Dynamic Properties of the Infrared Cesium Arc" was the title of a paper by J. M. Frank (A '43) and W. S. Huxford, Northwestern University, Evanston, Ill. The cesium vapor arc is an efficient source of infrared radiation for optical communication purposes. About 25 per cent of the input power is emitted in the resonance lines at 8,521 and 8,944 Angstrom units. A high degree of modulation of these lines is produced by current modulation of the d-c discharge. The dynamic electrical properties of the type *CL-2* lamp have been determined for the range of frequencies from 50 to 10^6 cycles per second. Below 20,000 cycles per second the reactive component is inductive in character, while at higher frequencies it is capacitive. The radiation-current modulation ratio depends on the frequency and depth of current modulation in the d-c biased arc. For the lower frequency range up to 2,000 cycles per second, this ratio has a value of 0.85 for a normal arc. At higher frequencies it varies inversely as the square root of the frequency. A type of phase modulation exists between the arc current and radiation flux in which the angle by which the current leads the light changes as a function of frequency, increases to a maximum at 30,000 cycles per second, and then decreases at higher frequencies.

It is possible to detect a modulated infrared beam by irradiating a supersonic field and observing the resulting changes in sound pressure amplitude at a suitably placed detector. This interesting investigation was reported in a paper called "Supersonic Detection of Infrared Radiation," by F. J. Fry (A '41) and W. J. Fry of the University of Illinois, Urbana, Ill. Two distinctly different types of coupling have been observed. The first is due to a heating of the gas under irradiation. This results in a change in wave length of the sound so that if a detector crystal is placed at a fixed distance from a driver crystal and a standing wave set up between them, the position of the detector crystal with reference to a peak of the standing wave will shift periodically with the infrared modulating frequency. The magnitude of the effect decreases rapidly as the modulating frequency is increased. For example, if the frequency is doubled, the magnitude of the coupling is approximately halved. The second type of coupling has been observed by irradiating a column of carbon dioxide gas which is excited at a supersonic frequency corresponding to maximum acoustic absorption. As is well known, this frequency of maximum supersonic absorption can be shifted about by the addition of small amounts of water vapor to the carbon dioxide. Most of the measurements reported in this paper have been taken at 922 kc which requires roughly one per cent water vapor for peak absorption. In this case there is a negligible standing wave in the gas column when the separation is greater than ten wave lengths. When the gas is irradiated under these conditions there is no appreciable decrease in the magnitude of the coupling effect as the modulating frequency is increased. This is distinctly different from the other type of coupling and it indicates that this effect is not dependent on heating the gas. Experiments so far have been restricted to modulating frequencies less than 100 cycles per second, however, it is felt that on the basis of a presently proposed explanation of this effect that there will be no large decrease in the magnitude until the modulating frequency approaches the frequency of the supersonic field.

TELEVISION

"The Chromoscope—A New Color-Television Viewing Tube" was discussed by A. B. Bronwell (M '44) of Northwestern University, Evanston, Ill. The chromoscope is an all-electronic color television viewing tube for receiving color television pictures. It contains a single electron gun and a composite image screen. The image screen contains three screens, each of which is coated with a different color phosphor, corresponding to the three primary colors. These screens are optically superimposed but separated a short distance apart and electrically insulated from each other. By controlling the potentials on the screens, any one of the screens can be made to fluoresce. The screen potentials can be commutated electronically so as to obtain any desired color sequence. The observer sees the three color images superimposed upon each other, thereby forming a composite colored image. With the chromoscope it is possible to change color at the end of every

line instead of at the end of the frame, thereby eliminating color breakup in the received image.

"Color in Television Cathode-Ray Tubes" was discussed by Edith B. Fehr, of the General Electric Company, Schenectady, N. Y. In black and white television the color, or rather shade of white, of the picture tube is an important quality item. In choosing a desirable color, several physical and psychological factors must be considered. A bluish white color corresponding to the color of a black body radiator at 6,500 degrees Kelvin represents the best compromise. Three methods are available to specify color in general: spectrophotometric curves, relative transmission through a series of filters, and comparison with an accepted collection of samples such as the Munsell system. All three methods can be used for specifying color in television cathode-ray tubes. Method one or two is preferred, because they yield quantitative results and permit specification of color in terms of the system adopted by the International Commission on Illumination (ICI system). Several instruments suitable for measuring color in this system were described.

PICKUP EQUIPMENT

A brief review of the characteristics of the more widely used types of electronic television pickup tubes was covered in the paper, "New Television Field Pickup Equipment," by John Roe of the Radio Corporation of America, Camden, N. J. This review traced the trend toward greater sensitivity culminating in the image orthicon. This development has resulted in the present-day ability to televise on unlimited variety of subject matter. Former restrictions imposed by requirements for large amounts of illumination have been removed almost entirely. An important by-product of higher sensitivity is the possible increase in depth of focus of the optical system. Field or portable equipment has been designed to take advantage of the improved characteristics of the image orthicon. This design lends itself to a maximum of flexibility for various types of operation, including use in studios and in mobile units. Most of the units are shaped like a medium-sized suitcase. The camera includes a 4-position lens turret and an electronic view finder. Camera cables may be as much as 1,000 feet long and electric interconnections are simple and few in number. Each of the major units is described in some detail, along with its function in the system.

A paper dealing with the design of monitoring equipment suitable for television broadcasting station application and the measurements required to prove performance was "Monitoring Equipment for Television Broadcast" by M. Silver, International Telephone and Telegraph Corporation, New York, N. Y. This monitor is used for monitoring the frequency of the video transmitter. Briefly, the sound monitor operates as follows: A portion of the transmitter output is mixed with a crystal standard so that the difference frequency is 150 kc. This voltage is applied to a counter-type discriminator which is used both to measure the transmitter frequency and monitor its audio output. The required linearity for this application is extremely high, in the case of this equipment, 0.02 per cent. The output of the counter discriminator is filtered and then applied to an audio amplifier for acoustic monitoring and measurement purposes. In addition, the discriminator feeds a suitable vacuum tube voltmeter for percentage modulation measurements and a thyratron flasher circuit for overmodulation indication. For operation of the video frequency monitor, a portion of the unmodulated transmitter output is mixed with a standard reference crystal so that the difference frequency is 15 kc. This output is applied to a counter-type discriminator used for measuring the transmitter's frequency. The circuit contains a complete calibrating system so that the accuracy of the monitor indication may be checked. The sound monitor is capable of measuring noise to minus 85 decibels and distortion of 0.2 per cent. Carrier frequency for both sound and video can be measured to an accuracy of plus or minus 100 cycles under full modulation conditions with a long time stability of one part in 5×10^8.

FREQUENCY MODULATION DEVELOPMENTS

"A New 50-Kw Frequency Modulation Transmitter" was described by C. J. Starner, Radio Corporation of America, Camden, N. J. This paper presented a brief history of the development of final stages of a 50-kw transmitter for the original 42 to 60 megacycle frequency modulation band, and the subsequent evolution of the equipment for the 88 to 108 megacycle band. A brief description of tube development problems as a parallel to circuit problems was also included. A detailed description was given of the RCA type *BTF-50A*, an air-cooled 50-kw transmitter operating in the frequency range of 88 to 108 megacycles. Attention was focused primarily on the output stages of the transmitter, which are self-contained coaxial-line-type units of novel construction using air-cooled triodes of modern design in "grounded grid" operation.

A new type of frequency modulation station monitor that is accurate, simple to operate, and does not require continual adjustment, was described in a paper called "A Pulse-Counter-Type Frequency Modulation Station Monitor," by D. Packard (A '35) and N. B. Schrock, of the Hewlett-Packard Company, Palo Alto, Calif. The principal feature of this meter is the method used for the measurement of the mean frequency of the frequency modulation carrier and for the measurement of the instantaneous frequency swing. The basic circuit used is a pulse-counter type operating at a mean frequency of 200 kc. A constant direct current equivalent to a fixed carrier of 200 kc is subtracted out, thus providing a zero center deviation indication. This current is stabilized so that the zero deviation reading is substantially independent of line voltage changes, temperature changes, and changes of tubes. The same pulse counter circuit is used as a discriminator and features excellent linearity coupled with extremely low hum and noise. Circuits are provided also for over-modulation alarm and for distortion and frequency response measurements.

TRANSATLANTIC TRANSMISSION

"The Possibility of Transatlantic Transmission by Means of Frequency Modulation" was the title of a paper by L. B. Arguimbau and J. Granlund of Massachusetts Institute of Technology, Cambridge, Mass. Frequency modulation makes an improvement of some 30 to 1 over amplitude modulation in the suppression of common-channel interference between two broadcast programs. The phenomena of multipath distortion and fading are essentially due to the interference between two or more signals arriving from the same transmitter by paths differing in time delay and efficiency. Thus improved multipath reception might be expected with frequency modulation. The problem was analyzed on a semi-static basis by considering the interference between desired and undesired, contact frequency signals. When the ratio of amplitudes is near one, the instantaneous resultant frequency varies periodically at the difference frequency rate. The average value of the resultant frequency is always exactly the frequency of the larger signal. However, the resultant frequency hovers near the average frequency of the two signals most of the time, but has sharp frequency deviations or spikes of peak variations $a/(1-a)$ times the difference frequency. If the receiver gives linear response over this larger frequency range, the direct component of the voltage output corresponds to the frequency of the larger signal and is not influenced by the presence of the smaller. If the receiver does not pass the spikes the smaller signal interferes with the reception of the larger. Two paths differing by 0.5 millisecond were constructed using a mercury supersonic delay line. A laboratory receiver having a 4-megacycle bandwidth for all parts following the limiter and operated with plus or minus 75-kc deviation gave essentially interference free results when the paths differed by one decibel or more. It is the author's opinion that distortion-free transatlantic channels can be provided by these foregoing methods.

"Phase Modulation Circuit" was described by S. M. Beleskas, of the Radio Corporation of America, Camden, N. J. The circuit was described and a mathematical solution and vector diagrams were evolved. The theoretical limit of the circuit is plus or minus 90 degrees. It was shown how plus or minus 90 degrees modulation can be utilized for communication transmitters with only ten per cent distortion. The circuit contains no resonant circuits, therefore, it is not subject to any critical adjustments. Phase modulation is produced without the presence of amplitude modulation.

INSTITUTE ACTIVITIES

Winter Meeting Site Famed for Engineering Industries

Historically, Pittsburgh means much to the electrical industry as a whole and to the Institute in particular. The a-c system of power distribution, which is used universally today, found its taproots here, and one of the first and largest of the Institute Sections likewise originated in Pittsburgh. The city contributed many outstanding men who became prominent in the management of Institute affairs.

Sixty per cent of the total population of the United States falls within a 500-mile circle centered on Pittsburgh, and the great majority of engineers come from this 60 per cent. They can reach the city in a short night's run over any one of five railroads.

Pittsburgh offers unequaled facilities for inspection trips to a large number of plants in the so-called "heavy engineering industries." The United States Chamber of Commerce lists 34 items produced in such industries—blast furnace products, structural steel, forgings, castings, rolling mill machinery, electric machinery, boilers, and so on—and of the ten Districts listed east of the Rockies, the Pittsburgh District is the only one producing all 34 items. In the last prewar years it stood third in the total dollar value of production, and first in seven of the 34 items. It rightly has been referred to as the capital of big industry.

Pittsburgh is also an important research center. In addition to the Mellon Institute of Industrial Research, such important organizations as the Bureau of Mines, the Aluminum Company of America, H. J. Heinz Company, Gulf Oil Corporation, Pittsburgh Testing Laboratories, Vanadium Corporation, and Westinghouse Electric Corporation, have their research laboratories in the vicinity. Two well-known engineering colleges, the Carnegie Institute of Technology and the University of Pittsburgh, are located within the city limits, and Pennsylvania State College and West Virginia University are within short distances.

There is much to see in the Pittsburgh District and the coming meeting should be one of great interest, even apart from the sessions being prepared by the technical program committee.

INDUSTRY GROUP

Among the 13 sessions in prospect three will deal with power generation for steel mills, power distribution in large mills, and power distribution in the mining industry. The first of these will cover the economic and engineering aspects of utility company ties with steel mills having their own generating equipment. The second session will treat the selection of voltage for steel mills and large glass plants, as well as a new low-voltage a-c bus design suitable for use in large mills. The third session will have to do with the general subject of d-c short circuits in mines, and also some of the power supply problems encountered in large strip mining operations.

A session on industrial control will embrace papers on control of supercalender drives, the liquid rheostat for speed control of wound rotor induction motors, and improvements in rolling mill preset screw-down controllers. A conference on the same subject will consider a variety of subject matter: pinhole detectors, adjustable voltage control equipments, safety in the design of machine tool control equipment, two overload relays versus three on 3-phase systems, and current limiting power fuses in control equipment.

A session on material handling will have topics as follows: selection of d-c series motors for crane application, application of new mill-type motors, and electric drives with fluid couplings for material handling equipment. Still another session on machine tools will deal with electrical engineering in this industry, the application of adjustable speed motors, and electric drives for planers.

Electronic and resistance heating will be the subject of another session, which will be concerned predominently with the induction and dielectric forms of electric heating. With respect to electronic heating, the economic aspects, interference from equipment, shielding of equipment, and performance will be considered. One paper will be devoted to industrial resistance heating.

The session on metallic rectifiers will commemorate the 25th anniversary of this type of rectifier and 25 years experience of copper oxide rectifiers will be described. Four or five discussions on the applications of this type of rectifier will be given.

A session on electrothermal processes will treat electrode control for arc furnaces, the electric equipment and operation of ferro-alloy furnaces and graphitizing furnaces.

POWER GROUP

In the field of power generation a series of papers will deal with generator stability at low excitation, electronic exciter performance, rototrol excitation, and applications of regulex exciters.

A session on relays will have papers which deal with impedance as seen by phase and ground relays during faults and power swings, as well as differential protection of substation buses.

Extra-high-voltage cable systems will be the subject of another session. A series of five papers will cover the latest developments in the design and installation of these cable systems. Interesting and valuable data will be presented on the following installations of oil-filled cable and cable installed in a pipe under high gas or coil-pressure: 69 kv in Philadelphia, 115 kv in New Orleans, 120 kv in Detroit, and 138 kv in Long Island. In the operation of the gas-pressure system, one of the problems encountered is locating leaks in the pipe. A method developed for this purpose will be described.

Two sessions on switchgear are in prospect. The first will deal with power system tests up to 7.5 megavolt amperes on 230-kv circuit breakers. The second session will comprise a study of fault currents and a new circuit breaker for fault current interruption.

Another session will deal with electronic power converters and papers have been promised on performance of mercury-arc rectifiers, on operation of large d-c motors by rectifiers, and application of mercury-arc rectifiers for induction heating. There will be a report on European developments in this field, as well as a report on the bibliography for electronic power converters.

A conference on mechanical rectifiers will be held. The development of the high-current mechanical rectifier in Germany during the war has revived interest in that subject in the United States. Conference papers will be presented on the history, the problem of commutation, the German mechanical rectifier, and on commutating reactors.

COMMUNICATION AND SCIENCE GROUP

In the field of communication six sessions are in prospect on subjects as follows: general communication, facsimile, magnetic recording, telephone and telegraph switching, synthetic crystals, and radio relays.

In the field of electronic instruments plans are being made for a session with a variety of subject matter, such as stable d-c amplifiers, double-conversion d-c feedback amplifiers, and the like.

Arrangements are being made for a conference on some new electronic devices and applications with a selected group of speakers, some of whom will utilize demonstrations in connection with their presentations.

Hotel	Approximate Hotel Rates			
	Single Bed	Double Bed	Twin Beds	Suites
William Penn	$4.25– 7.00	$6.25–10.00	$7.00–13.00	$14.00–60.00
Roosevelt	3.75–10.00	5.50– 6.50	7.00–12.50	
Pittsburgher	3.50– 5.00	5.00– 6.00	6.50– 7.00	12.00–14.00
Keystone	3.25– 4.00	4.75– 6.00	7.00– 8.00	
Henry	2.00– 4.75	4.00– 7.25	4.25– 7.25	
Fort Pitt	2.00– 5.25	3.25– 6.25	6.25– 8.00	
Schenley (Oakland section)	4.25 up		7.00 up	
Webster Hall (Oakland section)	2.50– 5.00	6.00– 7.00	4.00– 7.70	

In the field of research a session will be sponsored on the subject of new materials of interest to electrical engineers. New insulating and dielectric materials and new metals and alloys used as conducting and magnetic or semiconducting bodies will be discussed. Many of these materials are the result of wartime research and development. Some will have a profound effect on the future design of electric equipment.

In the basic sciences field conferences are planned on applied mathematics, large-scale computing devices, and network circuit theory. Arrangements also are being made for a session on servomechanisms.

GENERAL APPLICATIONS GROUP

In the field of transportation a symposium on railroad electrification, a session on heavy traction, and another on light traction are being arranged. The symposium will treat the economics of the electrification of railroads with moderate traffic density. Elements of electrification costs, which will be covered, include overhead trolley construction, distribution systems, power delivery and conversion, and electric locomotives. The heavy traction session will be comprised of papers relating to certain aspects of main line diesel-electric locomotives and others relating to electrified railroads. The light traction session will consist of a variety of papers covering both power distribution equipment and rolling stock for urban transit.

Electric heating of houses will be the subject of another session, which will feature both the heat pump and resistance heating. The objective of the session will be to familiarize members with developments to date in these fields and to stimulate further investigation.

Arrangements are in progress for a conference on safety, which will be of interest in several broad fields of activity.

ETA KAPPA NU RECOGNITION DINNER

The Eta Kappa Nu recognition dinner will be held Monday evening, January 26, in the Urban Room of the William Penn Hotel. W. J. Lyman of the Duquesne Light Company has been appointed chairman of the Pittsburgh arrangements for this dinner.

INSPECTION TRIPS

Arrangements are being made for the following trips to industries in Pittsburgh and the vicinity:

1. Copperweld Steel Company, Glassport, Pa.

The manufacture of copperweld steel products will be shown and the facilities for producing and controlling the products demonstrated.

2. Irvin Works, Carnegie-Illinois Steel Corporation

This is the largest steel plate rolling plant in the world. A view of the equipment and its operation will be inspected.

3. Pittsburgh Plate Glass Company, Creighton, Pa.

This company is the largest manufacturer of plate glass in the world. The operation of this plant will show how some of these products are made.

4. Springdale Power Plant, West Penn Power Company

This plant has seven large generators the most recent one being an 81,250-kva 3,600-rpm unit. There is also an ignitron rectifier exciter.

5. Dravo Corporation, Neville Island

Construction on towboats and large freight barges will be on view and the mass-production arrangements for building these craft will be evident.

6. Westinghouse Electric Corporation, East Pittsburgh Works

This trip will cover the manufacture aisles on large generators, circuit breakers, and allied equipment. In addition, a demonstration of large circuit breaker operation will be given in the high-power testing laboratory.

7. 10,000-kva series capacitor in 66-kv circuit, Duquesne Light Company

This largest and highest voltage series capacitor will be shown in operation carrying a circuit load of approximately 50,000 kva. Certain protective devices will be in view.

8. Aluminum Company of America Research Laboratories, New Kensington, Pa.

Will visit the various divisions of this modern research laboratory, which include metallography, paints, mechanical testing, and analytical laboratories

9. Bureau of Mines Explosives Testing Station, Bruceton, Pa.

A mine explosion will be demonstrated and an opportunity will be given for visitors to inspect the test mine.

Arrangements will be made to visit the following places on several days or daily during the meeting:

10. University of Pittsburgh cyclotron

A trip to see the operation of this equipment will be scheduled for several different days. The equipment and its practical uses will be explained.

11. Heinz 57 Varieties Factory

Visitors may inspect this plant at certain times on any of the days of the week of January 26. Processing, preparation, preserving, packing, and so forth, of various food products will be observed.

12. Buhl Planetarium

The Planetarium may be visited any evening. Displays of electric devices will be in evidence.

13. Inclined railway

Opportunities will be given for visitors to ride on one of the inclined railways—probably the one which goes up Mount Washington so that a view of downtown Pittsburgh can be seen.

HOTELS

For convenience, the approximate rates of several hotels, including the meeting headquarters hotel, are listed. Those

View showing process of reducing the carbon content of a 35-ton high grade alloy steel heat in a 10,000-kva 3-phase Heroult-type electric arc furnace in the Crucible Steel Company of America plant at Midland, Pa., near Pittsburgh

who will attend the meeting should make reservations by writing directly to the hotel preferred. Although arrangements have been made for sufficient rooms for the number expected to attend, they will be held only if specifically reserved by those who will occupy them. It is desirable for members to double up if possible as there are only a limited number of single rooms. All members who will attend are urged to make reservations promptly.

ADVANCE REGISTRATION

Members should register in advance by filling in and mailing the advance registration card as soon as received in the mail. This will assist the committees in making arrangements and save time at the registration desk on arrival. A nonmember registration fee of $2 will be charged all nonmembers except members of the Association of Iron and Steel Engineers, also members of the American Mining Congress, who have been invited to take part in the industry group sessions; enrolled Students; and the immediate families of members.

COMMITTEES

The members of the general committee for the 1948 winter general meeting are

C. A. Powel, *chairman;* C. T. Sinclair, *vice-chairman;* L. N. Grier, *secretary-treasurer;* H. S. Fitch; Paul Frederick; J. R. MacGregor; A. C. Monteith.

Subcommittee chairmen are

M. S. Angier, *entertainment;* R. L. Dunlap, *finance;* M. Getting, *publicity;* R. C. Gorham, *meetings and papers;* A. A. Johnson, *inspection and transportation;* B. M. Jones, *registration and information;* Mrs. G. A. Price, *ladies' entertainment;* C. M. Skooglund, *hotels.*

AIEE's New National Meeting Gets Off to a Good Start at Chicago

With a verified registration of 1449, the first in the fourth and newest series of AIEE national meetings was held at the Congress Hotel in Chicago, Ill., November 3–7, 1947. The high attendance and the extent of active individual participation in this meeting would seem to constitute a vindication of the judgment of those whose foresight and planning led to the establishment of this new series of meetings, known officially as AIEE Midwest general meetings, which is expected to be held annually somewhere in that vast area generally known as the "Middle West," the better to serve AIEE members in that area. The Milwaukee Section has asked for and received the sponsorship for the meeting in the fall of 1948, and there is conversation about Cincinnati, Ohio, for the fall of 1949.

Heretofore, there have been but three series of AIEE national general meetings, the summer, the winter, and the Pacific Coast. Traditionally, the annual summer general meeting is held each year in a different city, in response to invitations from AIEE local Sections or District groups. These meetings usually are held in June. The 1947 meeting was held in Canada at Montreal; the meeting in June 1948 will be held in the city of Mexico in the Federal District of Mexico. The winter general meeting traditionally is held around the latter part of January in each year and usually in the city of New York, although occasionally in response to urgent invitations this general meeting may go afield, as it did in 1941 to Philadelphia, and as it will in January 1948 to Pittsburgh, Pa. On the Pacific Coast, the AIEE Pacific District, Northwest District, and the Vancouver Section of the Canadian District have co-operated since 1910 in holding an annual general meeting somewhere in their combined areas. Thus, with the establishment of the Midwest general meeting, national meeting activities are placed within reasonable convenient reach of a large proportion of AIEE's individual members. It is planned also that the program of District meetings will continue to grow and develop in accordance with the local needs and interests of the several districts.

HEAVY PROGRAM

The working program for the Chicago meeting was made up of three general sessions, seven technical sessions, and nine technical conference sessions, including one held jointly with the National Electronics Conference at the Edgewater Beach Hotel; the regular fall meeting of the AIEE board of directors; and about 40 formal and informal meetings of AIEE technical, general, and administrative committees, ranging from 6:30 a.m. breakfast meetings of the industry co-ordinating committee to the evening after-dinner meetings of the technical program committee and the electronics committee. The opportunity for these fall working meetings of committee groups materially should strengthen AIEE's rapidly expanding activities program.

HULL SPEAKS TWICE

AIEE President Blake D. Hull (F '39) was the feature speaker at the opening general session of the AIEE meeting, Monday morning, November 3, and also was the feature speaker before a general joint luncheon gathering with the National Electronics Conference at the Edgewater Beach Hotel, Tuesday noon, November 4.

At the opening AIEE session, President Hull spoke under the subject title "Ceiling Unlimited," in which address he dwelled at length upon the closeness of the interrelationship and interdependence which actually exist today among the various branches of engineering and science. At the AIEE–NEC luncheon meeting, President Hull spoke on the topic "An American Engineering Association," in which he spoke strongly of the "crying need for an organization devoted to the general, professional, and nontechnical needs of the individual members of all branches of the engineering profession," stating further that "at present, there is no single society qualified or authorized to promote and protect the general welfare of the individual engineer." President Hull stated that, although he had no fault to find with nor particular change to suggest in the technical activities as presently handled by the various national engineering organizations, he did believe that there is a common field in nontechnical matters that is of common interest and should be of some common concern; that in his opinion, the question of appropriate organization of "a single great national engineering organization is an issue which is ducked consistently by responsible leaders of the several engineering societies."

FERMI DISCUSSES ATOMIC ENERGY

"The Future Prospects of Atomic Energy" is the subject of an address which was delivered before a general session Tuesday, November 4, by Doctor Enrico Fermi of the University of Chicago's Institute of Nuclear Studies. In his address, Doctor Fermi, a well-known authority and leader in atomic research, declared that he does not believe that atomic power will be a serious competitor to conventional fuels for at least several decades. He stated that the chief problem is one of metallurgy. He held that the biggest and most immediate promise for the practical use of the results of atomic research lies in the field of medicine, probably both for diagnosis and corrective treatment. He cited the rapidly growing use of radioactive materials for "tracings" in the study of the human body and some of its critical ailments.

SYKES ON STEEL PROBLEMS

"Problems of the Steel Industry" was the subject of an informal talk delivered before a general session Tuesday morning November 6, by President Wilfred Sykes (F '14) of the Inland Steel Company. Mr. Sykes considers that "the future of steel is the future of America," and urged that the United States should keep clear of all government regimentation, cartels, monopolies, and price fixing, and should retain the "free play of initiative and the opportunity to develop under a free-enterprise system," to maintain industrial world leadership.

Mr. Sykes spoke particularly strongly against what he considers to be the possible trend of government into the steel industry. The steel industry, according to Mr. Sykes, has been attacked for its lack of capacity to meet immediately the huge postwar needs. He pointed out that these attacks come from the same source which in 1939 attacked the steel industry because it then was supposed to be overbuilt and thereby contributing to the depression of the 1930's. Mr. Sykes was strong in his opinion, and "in the opinion of many well-informed people in Wash-

ington," that these attacks "come from a group who want to enslave the United States in a planned economy, and by such attacks hope to discredit and harass primary industries in order to create a popular demand for government operation." "If the Government should get into the building and operating of steel plants," Mr. Sykes continued, "we could expect to see steel products sold at prices that would not permit private enterprise to continue. This," he added, "would be the opening wedge for the socialization of all United States industry."

Mr. Sykes, in discussing normal demands on the steel industry, based his conclusions on the historic approach. The best guide, in his opinion, is to consider consumption on a per-capita basis. He pointed out that there was a 666-pound consumption per capita average between 1911 and 1920; 770 pounds per-capita average between 1920 and 1930; 576 between 1920 and 1940; an over-all average of 668 pounds per capita from 1920 to 1940. Mr. Sykes offered these figures in rebuttal to the general thought prevalent now that the pound consumption per capita has been increasing steadily over the years. He indicated a peak demand of as much as 1,060 pounds per capita might be expected perhaps by 1950. "Today the steel industry," said Mr. Sykes, "has an estimated capacity of over 91,000,000 tons. With a supply of approximately 1,300,000,000 tons estimated still to be in the vast Mesabi range, plus unexplored regions of Canada and unproved deposits in Labrador, there will be adequate iron-bearing material for many years to come."

ENTERTAINMENT PROGRAM

The purely entertainment feature provided for the men attending the Midwest general meeting in Chicago was an informal dinner–smoker held Thursday evening, November 6, in the Casino Room of the Congress Hotel. A social hour preceded the dinner, and a floor show followed the dinner.

Events especially arranged for the women included an informal lecture tour of the Art Institute followed by tea in the Institute club rooms Tuesday, November 4. The Art Institute houses one of the finest art collections in the United States, including what is said to be the most complete collection of modern French paintings. Included in the tour for the women was Mrs. Thorne's well-known miniature rooms. On Wednesday November 5, the women were invited to accompany the men to a luncheon at the Museum of Science and Industry, followed by a tour of the Museum. Thursday afternoon, there was a luncheon and bridge party for the women at the Saddle and Cycle Club on Chicago's North Shore.

INSPECTION TRIPS

A heavy program of seven major inspection trips was so planned with reference to the technical program to reduce to a minimum the conflict in interest between the subject matter of the paralleled sessions and inspection trips.

At the Fisk station of the Commonwealth Edison Company, visitors had the privilege of inspecting the oldest (1903) and the second largest (300,000 kw) electric power station in Chicago. They were able to see, operating side by side, a vertical 12,000-kw 9-kv 25-cycle turbogenerator in service since 1909, and a modern 147,000-kw 12-kv 60-cycle single-shaft tandem-compound unit.

At the Archer Avenue Plant of the Western Electric Company, a supply unit of the Bell System, visitors were shown the various phases in the making of telephone instruments.

At the South works of the Carnegie-Illinois Steel Company, a subsidiary plant of United States Steel Company, visitors were shown many of the interesting features of the second largest steel plant in the world, which has an annual steel production capacity of 4,525,000 tons, and covers various square miles of ground.

Not for the purpose of merchandise display, but for the purpose of inspecting the lighting, air conditioning, and other engineering installations of one of the world's famous department stores, a special inspection trip limited to 150 persons was arranged through the Marshall Field and Company store, Wednesday evening.

At the Armour Research Foundation, visitors were shown something of the inner workings of this nonprofit organization which, with a staff of more than 300 people, has seven major research departments, which are reported to have completed more than 7,000 research projects with some 1,900 companies, government agencies, and trade and professional associations.

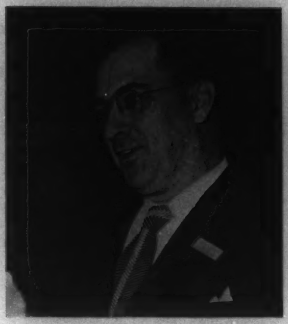
About the most popular feature of the inspection program was the trip to the electromotive division of the General Motors Corporation at La Grange, Ill., where visitors saw parts of the 54-acre plant which claims a production schedule of four road locomotives and one switching locomotive each working day, each locomotive requiring the assembly of some 70,000 parts.

COMMITTEES

In substantial measure, credit for the smooth working effectiveness of the first of the AIEE Midwest general meetings goes to the following committee personnel who really made it work:

General Committee

F. H. Lane, *chairman;* Dwight L. Smith, *vice-chairman;* F. V. Smith, *secretary;* N. C. Pearcy, *treasurer;* D. L. Bement; O. W. Eshbach; J. E. Hobson; L. R. Janes; P. B. Juhnke; T. G. LeClair; J. R. North; R. I. Parker; H. K. Smith; Earle Wild



A. C. Monteith speaks at the Monday symposium on the Tidd 500-kv test line during the recent AIEE Midwest general meeting

Meetings and Papers Committee

A. J. Krupy, *chairman;* K. V. Glentzer; E. R. Hendrickson; T. O. Millard; H. E. Nason; E. G. Norell; J. J. Samson; G. B. Smedley

Hotels Committee

J. E. Hobson, *chairman;* W. M. Ballenger; W. A. Clinnin; A. N. Eliasen; C. A. Emery; R. W. Jones; L. B. LeVesconte; L. W. Matsch

Publicity Committee

R. I. Parker, *chairman;* P. B. Garrett, T. C. Sullivan

Inspection Trips Committee

L. R. Janes, *chairman;* E. A. Armstrong; H. A. Croll; H. J. Decker; Sam Ein; H. F. Fruth; H. R. Heckendorn; E. A. Imhoff; M. J. Maiers; M. V. Maxwell; T. O. Millard

Finance Committee

P. B. Juhnke, *chairman*

Registration Committee

R. R. O'Connor, *chairman;* W. J. Behrens; W. F. Bergmann; G. E. Buchanan; S. L. Chapin; D. K. Chinlund; V. E. James; J. E. Kearns; W. A. Knight; H. E. Nason; W. E. Nelson; J. P. Tegel

Dinner and Entertainment Committee

H. K. Smith, *chairman;* C. P. Christensen; F. A. Cox; H. A. Cornelius; M. R. Gowing; John Romano; Willard Taylor; F. D. Troxel; J. C. Woods

Ladies Committee

Mrs. F. H. Lane, *chairman;* Mrs. D. L. Bement; Mrs. O. W. Eshbach; Mrs. J. E. Hobson; Mrs. L. R. Janes; Mrs. P. B. Juhnke; Mrs. T. G. LeClair; Mrs. R. R. O'Connor; Mrs. R. I. Parker; Mrs. N. C. Pearcy; Mrs. Dwight L. Smith; Mrs. F. V. Smith; Mrs. H. K. Smith; Mrs. Earle Wild

Analysis of Registration at 1947 Midwest General Meeting, Chicago, Ill.

Classification	Districts 1	2	3	4	5*	6	7	8	9	10	Foreign	Total
Members	59	145	68	28	609	3	28	8	5	18	11	982
Men guests	18	27	7	7	221	1	5		1	4	9	300
Women guests	4	8	2		53	2	3					72
Students					90		1			1	3	95
Totals	81	180	77	35	973	6	37	8	6	23	23	1,449

* District in which Chicago is situated.

Two Sessions Devoted to 500-Kv Transmission Lines

The most significant development in many years in the field of electric power transmission is represented in the installation of 500-kv transmission lines at Brilliant, Ohio, adjacent to the Tidd steam-electric power station of The Ohio Power Company, which were energized officially at 500,000 volts at a public demonstration, October 1, 1947. Two entire sessions, comprising a total of seven technical papers, of the recent general meeting in Chicago were devoted to a discussion of the objectives and engineering features involved in this test project. C. F. Wagner (F '40) of the Pittsburgh Section was chairman of the session. The salient features of the project are reviewed in an article elsewhere in this issue (*pp 1178–87*). A digest of the Chicago sessions is given in the following paragraphs.

TRANSMISSION AT EXTRA-HIGH VOLTAGES

In a paper "Transmission of Electric Power at Extra-High Voltages," Philip Sporn (F '30) president of American Gas and Electric Service Corporation, New York, N. Y., and A. C. Monteith (F '45) manager of the headquarters engineering departments of the Westinghouse Electric Corporation, East Pittsburgh, Pa., discussed the general, technical, and economical considerations involved. They reported that the indicated need for developing higher-voltage transmission systems, and the fact that the costs of such systems increased rapidly with increased voltage, make increasingly important the careful and precise evaluation of all engineering factors entering into the design of such systems. This necessitates the determination of precise and reliable data on the characteristics and performance of materials and equipment. The two factors that influence design, and hence costs, of extra-high-voltage transmission lines and systems, are the inter-related factors of corona and basic insulation level. Subject to the determination of the answer to certain engineering questions, there is good engineering reason to believe that insulation levels materially lower than any heretofore attempted in extra-high-voltage transmission may be used successfully in the future.

Of the questions that need to be answered, thoroughly good engineering data already are available concerning lightning and switching surges, insulation co-ordination, and the effects of line spacing on reactance and capacitance. But line spacing also affects corona. Some data are available on corona and radio interference, particularly on fair-weather corona losses for horizontal configuration on single conductor per phase, and on the effects of conductor surface on these losses. However, there is need for data concerning corona loss and radio influence, showing the effect of ground wires on various combinations with single conductors, and the effect of fog and clouds. Also, the relative advantages and disadvantages of bundle conductors need to be investigated carefully. Answers to these and other questions are to be sought through the experimental operation of the 500-kv transmission lines.

CORONA CONSIDERATIONS

The "Corona Considerations on High-Voltage Lines and Design Features of Tidd 500-Kv Test Lines" were described in detail by C. F. Wagner, Westinghouse Electric Corporation, East Pittsburgh, Pa., Anthony Wagner of the American Bridge Company, Pittsburgh, Pa., and E. L. Peterson (M '31) and I. W. Gross (F '45) of the American Gas and Electric Service Corporation, New York, N. Y. The first important experimental work on corona was done about 1898 by Doctor Charles F. Scott at Pittsburgh, Pa., and was continued on the Telluride lines in Colorado. Subsequent observations were made, among others, by Converse, Mershon, Ryan, Peek, Whitehead, and Facciole. Peek developed and presented empirical formulas which for years were regarded as the best information available. Subsequently, the Ryan laboratory at Stamford University, and other Pacific Coast investigators, attacked the problem and provided much useful data. Corona-loss formulas reported in AIEE *TRANSACTIONS* in 1933 and 1937 have been confirmed closely by previously reported actual transmission-line test results, and do not at all agree with the results obtained by the Peek formulas in the range of 0.5–1 kw per mile fair-weather loss range which represents current transmission-line design practice. The proposed tests on the new Ohio installation are intended to extend this information into the realm of the higher voltages, above the present 287-kv limits.

There are three test lines, two 1.4 miles long, and a third single span of 800 feet. The two longer lines have an average span of about 1,050 feet, and run approximately parallel and about 288 feet apart, center to center. The line conductors are approximately 85 feet above the ground at the towers, and 40 feet at midspan. The experimental installation has been designed to accommodate the making of corona measurement on a full-scale transmission line energized by a full-size transformer and with other equipment closely similar to that which would be used in extra-high-voltage transmissions. Provision has been made to vary the conductor size, type, arrangement, and spacing; also to vary the number of insulators and the height of the ground wires.

INSULATORS

"Insulators and Line Hardware for Tidd 500-Kv Test Lines" were described in detail by I. W. Gross, R. L. McCoy (M '43) of the Locke Insulator Corporation, Baltimore, Md., and J. M. Sheadel (A'39), of the Ohio Brass Company, Barberton, Ohio. A preliminary study indicated no apparent advantage in attempting to develop any special insulator, or in using any intermixture of various insulator sizes or shapes in a string. Therefore, the conventional ball-and-socket 5$^3/_4$-inch spaced unit rated at 25,000 pounds was decided upon. It was concluded also that for a 3-phase 500-kv line, a maximum of 30 insulator units probably would not be exceeded in actual practice, and 26 insulator units would be sufficient for that part of the test layout where the insulators do not affect the measurements—that is, on the substation bus. Extensive laboratory tests indicated that shielding would be required on the line-end of insulator strings for two purposes: first, to grade the insulator string; and second, to control the electrostatic field around the line hardware in the vicinity of bolts, nuts, clamps, washers, and so forth. It was found also that no grading shield was required at the ground-end, or at any intermediate point on the insulator assembly.

LINE CONDUCTORS

"Line Conductors—Tidd 500-Kv Test Lines," was the title of a paper presented jointly by E. L. Peterson; D. M. Simmons (F '28) of the General Cable Corporation, Bayonne, N. J.; L. F. Hickernell (F '34) of the Anaconda Wire and Cable Corporation, Hastings-on-Hudson, N. Y.; and M. E. Noyes (M '30) of the Aluminum Company of America, Pittsburgh, Pa. The more important factors which entered into the selection and installation of conductors included conductance, outside diameter, exterior surface contour, facing, and material. In addition to the characteristics of the conductors themselves, careful consideration was given to the method of installation. To keep the conductors clean and free from abrasions, arrangements were made to string the conductors in such a manner that they could be kept off the ground during the stringing operation. As it is not planned to wash or clean the conductors, they will be in the same condition as the conductors would be on an operating line where it might not prove economical to take elaborate steps to clean the conductors. Where a cable had to be laid out on the ground, it was laid on planks to keep it off the ground surface.

The sizes of transmission line conductors selected for the Tidd tests included those of outside diameters of 1.4 inches, 1.65 inches, and 2 inches, a range which was believed to be adequate to give the necessary correlation for any intermediate sizes of single conductors which might be used in practice. In addition to these single conductors selected, the so-called "bundle," or grouped conductor arrange-

ment, will be tested, using individual conductors ranging in outside diameter from 0.7 to 0.92 inch, using from two to four conductors per phase. Both aluminum and copper conductors will be tested.

TRANSFORMERS AND LIGHTNING ARRESTERS

"Transformers and Lightning Arresters for the Tidd 500-Kv Test Lines" were described by F. A. Lane (M '31) of the American Gas and Electric Service Corporation, New York, N. Y., and by J. K. Hodnette (F '42), P. L. Bellaschi (F '40), and Edward Beck (M '35) of the Westinghouse Electric Corporation, Sharon and East Pittsburgh, Pa. The power supply equipment for energizing the high-voltage test line consists of a 5,000-kva bank of three single-phase transformers protected by lightning arresters. The same design methods, and the same methods of insulation, winding assembly, tank construction, tap-changer arrangement, and inert-gas preservation used on commercial shell-type transformers for present transmission voltages of 287 kv and below were extended and modified for use on these transformers. The core and coil assembly of the transformers is built into a form-fit tank, the two sections of which were welded together at the factory. This type of construction made possible the shipment of the unit complete in oil, except for the high voltage bushings and radiators, by laying each transformer on its side on a flat car.

The lightning arresters constructed for the Tidd tests utilized the same standard units used for some time in autovalve station-type arresters of all commercial ratings. As the neutral of the test system is grounded solidly, the arrester rating decided upon was 350 kv, 70 per cent of the maximum phase-to-phase voltage, a rating lower than the usual 80 per cent. The arresters have been assembled in two different forms, one a self-supporting arrangement, and the other a suspended arrangement.

SWITCHGEAR EQUIPMENT

In a paper entitled "Switchgear Equipment for Tidd High-Voltage Test Lines," F. A. Lane, and B. W. Wyman (M '46) of the General Electric Company, Philadelphia, Pa., described a single-pole unit which is being developed as an extension of the 287-kv low-oil-content impulse-type breakers originally developed for the Hoover Dam–Los Angeles transmission lines.

INSTRUMENTATION AND MEASUREMENT

"Instrumentation and Measurement for the Tidd 500-Kv Test Lines," were discussed by R. L. Tremaine of Westinghouse Electric Corporation, East Pittsburgh, Pa., and G. D. Lippert (M '46) of the American Gas and Electric Service Corporation, New York, N. Y. Atmospheric conditions, radio influence, and corona loss measurements, with especial emphasis on the last-named, are required with great accuracy. A detailed analysis of the possible errors inherent in the corona measurement methods heretofore used and reported upon in the AIEE *TRANSACTIONS* between 1924 and 1933, suggested the use of a new method for the current test installation. The circuit was designed on the following basis:

1. Corona power to be measured by a wattmeter located at a point of high potential to eliminate the necessity of subtracting transformer losses.
2. Wattmeter potential to be taken from an extension of the transformer high-voltage winding.
3. Automatic compensation to be provided to correct for the phase-angle errors in the potential as applied to the wattmeter.

The system required the development of a special so-called "null" type of wattmeter which is about 100 times as sensitive as an ordinary wattmeter, and is classed technically as a "current-balance transmitter." The instruments are mounted in a housing on top of the transformer bushings and read by telescope from an elevated and enclosed observation post.

GENERAL DISCUSSION

The many discussors of the 500-kv test project included representatives from manufacturing, operating, and educational organizations located in North America, and one representative from France where a similar research project is under way. The general opinion indicated a desire for the attainment of technical knowledge and the establishment of basic data relative to the performance of electric apparatus at voltages higher than those heretofore used. A feeling of apparent confidence in the method of approach to the problem, and in the expectant results, was reflected in the various discussions. The participants in the research project were complimented very generally for their willingness to approach the problem with an open mind, and for the method of defining the research program on the basis of carefully considered objectives. Several of the discussors expressed the belief that the establishment of the intended basic data and principles of design would permit the future design of high-voltage transmission systems within limits very much closer than those that have been possible in the past through the use of empirical data, possibly even to the extent of changing design practices with reference to lower voltage systems. Caution was suggested in the making of economic analyses of system capacity increases utilizing these "higher voltage" operating units, inasmuch as the classification of these units as firm capacity may introduce elements of cost not considered at the present time.

Tubes and Relays Discussed at Joint AIEE-NEC Session

The AIEE and the National Electronics Conference shared one joint session at the Edgewater Beach Hotel during the recent meetings in Chicago. The session, under the chairmanship of C. H. Willis (F '42) professor of electrical engineering at Princeton University, Princeton, N. J., and member of the AIEE electronic power converter committee, was one of seven parallel sessions. Four conference papers were presented and discussed.

THE CONVECTRON

"The Convectron," was described by M. A. Babb (A '31) of the Bendix Corporation, Teterboro, N. J., as being a hot-wire type of dynamic vertical element of high sensitivity. This nonemissive type of tube gives direct electrical indication of position with no mechanically moving parts, the electric signal being produced through the use of a Wheatstone bridge circuit. Fine nickel wires located axially in each of two glass cylinders form the arms of a Y and join at a common terminal at the bottom. These two fine wires are connected with a balancing potentiometer to form the Wheatstone bridge circuit. The output voltage magnitude and phase angle corresponds to the direction of the vector which represents the resultant of all accelerations acting in the plane subtended by the two wires. The operating principle of the tube is based upon the fact that the convection cooling of an electrically heated fine wire in a gas varies with the angle between the axis of the accelerating force and the axis of the fine wire. The sensitivity of the tube is affected by the size and length of wire used, the pressure of gas within the tube and the kind of gas used, the temperature coefficient of resistivity of the wire, the applied voltage, and the angle between the wires. With two wires at an angle of 90 degrees, the output voltage is proportional to the sign of twice the angle measured from the vertical to the bisector of the wire angle. The time lag is approximately 0.1 second. There is a position of the "convectron" which, when balanced, will give the least change in null position for variations in supply voltage. A useful controlling signal is obtained from as little as a fraction of one minute change in position of the Convectron.

REED RELAY

"The Glass-Enclosed Reed Relay," was described by W. B. Ellwood of the Bell Telephone Laboratories Inc. New York, N. Y., as being a relay which combines high speed and a great uniformity of performance over long periods of time. The contacts are magnetic reeds sealed inside a glass tube which contains hydrogen gas. The operating winding is outside the glass tube. The relay requires no maintenance beyond unit replacement. A typical unit requires a minimum of 50 milliwatts to operate, and, with sufficient power, will operate in one millisecond. The unit occupies about three cubic inches of mounting space; its contact resistance is about 30 milliohms; the contacts load is limited to 25 watts or less. The contact life was described as being dependent upon circuit conditions; test units were reported to have operated over a range of from 3 to 1,000 million operations. This relay was discussed in some detail in an article carried in the recent November issue of *ELECTRICAL ENGINEERING* (*pp 1104–06*).

"A Capillary-Fed Mercury-Contact Relay" was described by J. T. L. Brown

(A '21) and C. E. Pollard of the Bell Telephone Laboratories, Inc., New York, N. Y. In this new type of mercury contact relay, the contacting surfaces are films of mercury-supported on solid metal. The mercury at the surfaces is replenished continuously through a capillary path to a mercury reservoir below the contacts. The relay consists of a small glass-enclosed magnetic transfer switch in the center of an operating coil in a metal vacuum-tube housing having an octal base. The switch is filled with hydrogen gas under high pressure. The combination of small sized parts, mercury-film contacts, and gas under pressure, results in a combination of performance capabilities which include very high speed, freedom from chatter, high current, and voltage handling capacity, and long life with stable characteristics. In the device, the mercury performs five important functions:

1. Continuously renewed contacts surfaces.
2. The damping of undesirable mechanical transients.
3. Bridges over mechanical chatter between the underlying contact elements.
4. Produces a high rate of effective separation of contacts.
5. Materially reduces contact wire.

This relay was described in some detail in an article published in the recent November issue of *ELECTRICAL ENGINEERING* (*pp 1106–09*).

NEW THYRATRONS

"A New Line of Thyratrons," was discussed by A. W. Coolidge, Jr. (A '42) of the General Electric Company, Schenectady, N. Y.

The author reported that, in accordance with increasingly stringent tube requirements imposed by the industrial control field, a line of gas-filled thyratrons is being developed to have certain distinct advantages over existing prewar types. Electronic motor control systems in particular, in order to be competitive with other types of motor control, progressively have demanded "more tube" for fewer dollars. The new demands embody quick heating, high peak-to-average current ratio, wide ambient temperature range, high surge-current rating, compactness, sturdiness, and reliability. A novel method of tube construction, in which the tube elements are spaced very closely, is proving to be an effective approach to the design of this new line, especially from the standpoint of meeting the technical requirements and also permitting relatively low-cost assembly. The construction is such that the tube may be loaded to a high gas pressure, an important factor in assuring long life in circuits having inductive loads. The author reported successful tests with thyratrons, having a fixed point for average current rating, used in circuits having inductive loads.

Communications Subject of Two Sessions Held During Meeting at Chicago

Two sessions under the chairmanship of J. L. Callahan (M '35) of RCA Laboratories, New York, N. Y., at the Midwest general meeting at Chicago, accommodated the presentation and discussion of four technical program papers and five conference papers covering a wide range of communications topics. The attendance averaged about 65 persons.

MOBILE TELEPHONE SYSTEM

"A General Mobile Telephone System," was described by H. I. Romnes (A '41) of the American Telephone and Telegraph Company, New York, N. Y. and R. R. O'Connor (M '43) of the Illinois Bell Telephone Company of Chicago.

Wartime needs accelerated the development of practical mobile radiotelephone equipment for use in the 30- to 200-megacycle range and emphasized the practicability and usefulness of mobile telephone service. After the war, the Federal Communications Commission made available a few frequency bands for experiments in this field, and during the past two years the Bell System has made mobile service available on an experimental basis in more than 60 cities, and about 100 more systems are under construction. Urban service is available in more than 40 cities, with two or three channels in service or under construction in eight of these cities. Highway stations in 22 cities provide continuous coverage between Chicago, Ill., and St. Louis, Mo.; New York, N. Y., and Boston, Mass.; New York and Buffalo, N. Y.; and New York and Washington, D. C. Also, the first units of highway systems in Wisconsin, Oklahoma, Indiana, Michigan, Ohio, and other states have been placed in service. Each of these mobile systems are designed to serve from 50 to 100 mobile units, depending upon the type of traffic involved. As of July 1, 1947, there were approximately 2,000 vehicles equipped for general mobile telephone service, and this number is increasing at the rate of about 200 per month. In April 1947, a DC-6 airplane operated by the United Airlines was equipped with telephone service on its inaugural transcontinental flight. Radio telephone service to railroad passengers is being furnished experimentally between New York and Washington on several trains on the Baltimore and Ohio and the Pennsylvania Railroads. A discussor suggested that vertical diversity might improve reception in mobile communications systems.

RADIO FOR TUGS

The application of "Very-High-Frequency Radio on New York Central Tugs" was described by G. M. Brown (A '45) electronics engineer for the New York Central System. As a result of tests conducted by New York Central Railroad and General Railway Signal Company engineers in April and May 1946, it was determined that very-high-frequency radio in the railroad band in the vicinity of 160 megacycles was capable of providing satisfactory and reliable communications within the lighterage limits of New York harbor. It was found also that the use of radio contributed in a great degree to the efficient utilization of railroad tugs, both by permitting routine orders to be transmitted from the tug dispatcher to the tug captains without delay or loss of time, and by making possible some modification of orders in emergencies. These conclusions have been borne out by the operating results obtained from such radio equipment since installed on 24 of the tugs operated by the New York Central System in New York Harbor.

In discussion, serious question was raised with reference to the low power (only 35 watt) used at both land and tug stations, but Mr. Brown stated that extensive tests had proved that the 35-watt power was sufficient to cover all of New York harbor area.

The "Standardization of Transient Response of Television Transmitters and Receivers," was discussed by R. D. Kell of the RCA Laboratories, Princeton, N. J. Mr. Kell reported that television transmitting and receiving equipment is becoming available that is beginning to have the electrical characteristics very close to those visualized by the engineers of the industry when they established the present television standards. Tests with this modern equipment have shown the soundness of the present standards, but at the same

AIEE PROCEEDINGS

Order forms for AIEE *PROCEEDINGS*, and abstracts of the papers included, have been published in *ELECTRICAL ENGINEERING* as listed below. Each section of *PROCEEDINGS* contains the full formal text of a technical paper including discussion if any, as it will appear in the annual volume of *TRANSACTIONS*. *PROCEEDINGS* are issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 976–8; Jan '47, pp 82–3*), and are available to AIEE Associates, Members, and Fellows.

Meetings	Abstracts	PROCEEDINGS Order Forms
Winter	Jan '47, pp 84–93; Feb. '47, pp 190–1	Feb '47, pp 33A and 34A
North Eastern District	Apr '47, pp 401–02	June '47, pp 55A and 56A
Summer General	June '47, pp 607–14. July '47, p 708	
Pacific General	Aug '47, pp 840–2	Dec '47, pp 55A and 56A
Middle Eastern District	Sept '47, pp 925–7	
Midwest General	Nov '47, pp 1125–8	

time have shown the necessity for additional standards pertaining to the phase or time-delay characteristics of the system. Inasmuch as a television picture is produced by signal transitions between half tone values, a most satisfactory method of testing system performance is through the use of electric signals representative of a transition between half tones. In keeping with the original plan, that the transmitter should have such a characteristic that the receiver performance would be the same on a double-side band as on the vestigial-type band of transmission, it is proposed that time-delay correction be placed in the transmitter to correct for the time-delayed distortion introduced by the vestigial sideband characteristic of the transmitter. In addition, it is proposed that time-delay correction be introduced in the transmitter circuits to correct for the time-delayed distortion introduced by the receiver's high-frequency cutoff characteristic. There is nothing in the standards that dictates to the receiver manufacturer what he shall build. The manufacturer is free to build what he thinks will sell. However, by including in the transmitted signal a standardized delay correction, better performing receivers for less money may be constructed. This should be the goal of all television receiver manufacturers.

TELEVISION GENERATOR

The "Television Radio-Frequency Signal Generator" described by Joseph Fisher, Philco Corporation, Philadelphia, Pa., was designed and built in the laboratories of the Philco research division to provide a source of modulated picture and sound carriers, unmarred by multipath transmission or noise, for research and engineering work on television circuits. The generator was designed to produce a signal corresponding to that radiated by a television transmitter. The output of the generator is connected to the antennae terminals of a television receiver by means of a transmission line, and a built-in attenuator is provided for changing the output level between the 100,000 microvolts and 1 microvolt. The generator consists of 10 chassis housed in a cabinet rack 83 inches high, a separate unit for each of the lower six television channels extending from 44 to 88 megacycles. The radio-frequency channel units consist of five shielded assemblies:

1. Harmonic mode crystal oscillator.
2. Buffer amplifier.
3. Sound final stage.
4. Picture final stage.
5. Attenuator.

A video amplifier is provided for each channel, with provision for changing the percentage modulation and black level of each picture carrier. A composite video signal of one volt peak-to-peak is required at the input of the video amplifier. This may be secured from a monoscope unit, camera change, or a cathode-ray-tube flying-spot scanner.

The sound unit contains a 4.5-megacycle reactance tube oscillator which may be frequency-modulated by either a built-in 400-cycle audio oscillator or by an external audio. The 4.5-megacycle signal is heterodyned against the unmodulated picture carrier to produce the final sound carrier. All of the television standards, such as crystal control of carrier frequency, negative modulation, percentage of the carrier devoted to synchronizing pulses, depth and linearity of modulation, and transmission of the d-c components, are adhered to. As the generator itself produces negligible noise, a very accurate check of masking and thermal noise produced in the input circuits of a television receiver, operating at low level, may be judged. The phase and frequency response of a television receiver may be evaluated by observing the reproduced picture. By applying a video sweep generator to the input of the "television radio-frequency signal generator," the over-all frequency response curve of a television receiver, from antenna terminals to picture tube grid, may be observed in an oscilloscope.

NAVY RADIO

"The Application of Western Union Multiplex to Navy Radio" was described by Ray Hoover (M '44) Western Union Telegraph Company, New York, N. Y. To meet the communication needs of World War II in the Pacific Area, a 4-channel Western Union type of multiplex was adapted to a single-channel frequency-shift radio system as an expedient method of providing a vitally necessary increase in communication channels. A 4-channel circuit was established between Washington, D. C., and Honolulu, Hawaii, and between San Francisco, Calif., and Honolulu within approximately nine months after the beginning of initial tests, and other systems followed in close session. Improvements in the radio and the use of the multiplex enabled the Navy to set up communication channels between the United States and all principal naval bases in the Pacific area. To make the multiplex system applicable to the Navy's communications system, a start-stop 7-unit teleprinter was substituted for the convention 5-unit multiplex printer. This substitution eliminated the necessity of manual retransmission from a multiplex radio circuit to a teleprinter radio circuit, or a land-line circuit. Because of the fundamental difference in operation of a multiplex system and a start-stop system, it was necessary to provide means on the receiving terminal distributor for converting the signals to the desired form. In addition to the terminal equipment for handling message traffic between two points, tape repeater equipment was furnished which made possible the joining of one or more channels of one radio-multiplex link with another multiplex or radio system without the necessity of manual handling at the junction point of the different systems. Translation equipment also was designed and furnished which made it possible to use standard Navy start-stop cryptographic equipment for transmission to and for reception from a multiplex channel.

Navy records show that it was not uncommon to maintain continuous 2-way transmission between Washington and Honolulu, and between San Francisco and Guam, over periods of from 20 to 22 hours out of each day. This enabled the handling of 240 words per minute in each direction on a single radio channel, or four times the number of words possible with a single teleprinter channel. Equal records were established in other radio links where the multiplex system was used.

FREQUENCY DIVISION TECHNIQUES

The "Frequency Division Techniques for a Coaxial Cable Network," which enable broader use of coaxial cables for telephone purposes were described by R. E. Crane (M '36), J. T. Dixon (A '39), and G. H. Huber (M '39) of the Bell Telephone Laboratories Inc. New York, N.Y. The coaxial cable system known as type *L1*, as presently designed by the Bell System, provides 480 long-haul message channels. By partially utilizing additional frequency space which is not satisfactory for long-haul circuits, an extra 120 short-haul channels can be provided. This gives a maximum circuit capacity of 600 1-way channels on a single coaxial circuit, as compared with 12 1-way channels per pair of wires, as obtained from earlier cable-carrier systems. The telephone-message carrying potentiality of the coaxial cable has required the development of concentrations of terminal equipment to prepare the messages for transmission, and to restore them to original condition at points where use can be made of large circuit groups. Another problem that has been involved in utilizing the cable's potentiality is that of removing and inserting relatively small groups of circuits at many points between the principal message centers. The general objective of the Bell System broad-band carrier development is to provide facilities giving satisfactory transmission and reliable service for telephone circuits up to 4,000 miles in length.

A telephone channel can be used for 18-channel voice-frequency carrier telegraph, or for facsimile and picture transmission. As the channels are designed primarily for

Future AIEE Meetings

Winter General Meeting
William Penn Hotel, Pittsburgh, Pa., January 26–30, 1948

Great Lakes District Meeting
Des Moines, Iowa, April 1–3, 1948

North Eastern District Meeting
New Haven, Conn., April 28–30, 1948

Summer General Meeting
Mexico, Federal District, Mexico, June 21–25, 1948

Midwest General Meeting
Milwaukee, Wis., October 18–22, 1948

Southern District Meeting
Birmingham, Ala., November 3–5, 1948

telephone service, the transmission requirements must be considered when other uses are made of the channels. For example, in picture transmission, equalizers must be provided for the delay distortion introduced by the band filters in the channel banks. Also, radio program channels of various band widths can be obtained by merging the frequency space of several telephone channels; for example, a single-side-band program channel has been developed which uses the space of three message channels and provides an 8-kc program band, and a control channel in addition.

Electronic Relays Applications Surveyed

A conference was sponsored at the Chicago meeting by the AIEE relay committee, A. J. McConnell (A '36) General Electric Company, Schenectady, N. Y., presiding, for the purpose of exploring, through the medium of informal discussion, the pros and cons of the use of electronics in power system protective relaying. Approximately 115 persons attended. In spite of the increasing use of electronics in the electric power industry, many relay engineers seem to be reluctant to use electronic protective relays. The purpose of this conference was to air the subject thoroughly through the exchange of practices and experiences. To form a basis for general discussion, two conference papers were presented, the first dealing with the more favorable aspects of electronic relays, the second reflecting the ideas of the relay committee's working group assigned to the subject, and discussing electronic relaying more generally including the less favorable aspects.

ADVANTAGES FOR PROTECTIVE RELAYING

"Advantages of Electronic Equipment for Protective Relaying," were discussed by R. I. Ward (A '41) of the Commonwealth Edison Company, Chicago, Ill. It is possible to design electronic protective relays that will meet practically any relay application and, if designed strictly from a relay engineering viewpoint, will have at least two major advantages over present relays: first, a minimum of moving parts, which will reduce the hazard of relay failure from mechanical defects or wear; second, a wider choice in the selection of relays, which could be manufactured locally and built to the purchaser's specifications as a majority of the parts are available at any radio wholesale house. It is believed that the advent of the electronic relay has been delayed for perhaps two reasons: first, lack of confidence in equipment using electronic tubes, a criticism with some justification based upon experience with tubes and radio receivers and in some instances with tubes in carrier-relaying equipment which are not as rugged as desirable (however, tubes can be constructed which are reliable and which have a long, useful life); second, development costs and obsolescence of present manufacturing equipment. The author reported that an electronic directional over-current relay experimentally developed and applied to the Commonwealth Edison system on a test basis had remained continuously in service for 30,000 hours without the characteristics of the relay or its tube changing sufficiently to affect the relay calibration. The authors expressed the opinion that practical experience over a period of years has shown that electronic relays not only are practicable, but have definite advantages over the present conventional relays, and that it is to be hoped that electronic relays will be given more serious consideration in the future.

PRACTICAL ASPECTS

In discussing "The Practical Aspects of Electronic Protective Relaying," F. W. Gross of the American Gas and Electric Service Corporation, New York, N. Y., summarized the familiar obstacles which exist in the application of electronic equipment to protective relaying and undertook to indicate the probable direction of future developments. While admitting that, in general, the functions which existing electromagnetic relays perform can be duplicated by electronic means, it must be pointed out that the new hazards to reliability which thereby are introduced do not justify such an application unless an improvement in accuracy, speed, or reduced costs is obtained, or unless the ability to perform some function not otherwise possible is attained. These various points were discussed separately. Presently, the widest use of electronics in relaying is in carrier-current relaying. Development of electronic relaying to date has been confined principally to accessory functions, and it seems probable that this trend will continue in the near future. For the longer range view, there is an almost limitless range of possibilities. New functions not otherwise possible are a constant challenge. Vision and imagination can produce new approaches to old problems. Perhaps conventional use of voltage and current can be replaced by better methods of fault determination.

Conference Devoted to Industrial Power Systems

A conference sponsored by the AIEE industrial power systems committee as a part of the program of the recent Chicago meeting, under the chairmanship of D. L. Beeman (M '43) of the General Electric Company, Schenectady, N. Y., drew an attendance of approximately 85 persons.

WIRING REPORT

Feature item of the program was the "First Interim Report on Interior Wiring Design for Commercial Buildings," a report of an AIEE subcommittee under the chairmanship of Benjamin F. Thomas, Jr. (M '29) chief electrical and mechanical engineer of the New York, N. Y., consulting engineering firm of Moran, Proctor, Freeman, and Mueser. A discussion of this report appears elsewhere in this issue (*p 1245*).

SHORT-CIRCUIT CALCULATIONS

In a conference paper, L. E. Fisher (M '38) director of research for the Bull Dog Electric Products Company of Detroit, Mich., described "Short-Circuit Calculations for Low-Voltage Industrial Distribution Systems." As an introduction to his discussion, the author pointed out that although the common practice in short-circuit calculation is to concentrate on *maximum* values, his proposed method shows not only the need, but also the means for considering *minimum* values as well. Only by considering both maximum and minimum values of short-circuit currents can the investigator fully appreciate the actual character of short-circuit conditions to be encountered in his system. In support of this contention, a most convincing slow-motion moving picture was shown of the arcing and fire caused in a 3-phase junction box by a short circuit involving only minimum values of currents.

Whereas the maximum value of a short-circuit current is needed for calculating the resulting forces on equipment, the selection of circuit breaker capacity, and so forth, the minimum value is equally important in deciding whether the speed of operation of the circuit interrupting device will be adequate to protect the bus and wiring systems. Conductor insulation may burn off, or the conductor itself may fuse under minimum short-circuit conditions.

The tests reported indicate that instead of applying circuit breakers or fuses on the basis of from 12 to 15 times the normal circuit current, a factor of only 5 is in many instances more protective, as it may prevent the destruction of equipment from minimum short-circuit currents. The author emphasized the great need for further quantitative tests along these lines.

AIR CONDITIONING EQUIPMENT

In a conference paper "Power Supply for Air Conditioning Equipment in Commercial Buildings," M. N. Halberg (M '43) and D. L. Beeman of the General Electric Company, Schenectady, N. Y., presented comparative cost figures covering typical air conditioning motors and control (in sizes ranging from 100 to 1,000 horsepower) together with the necessary distribution system within the building, for system voltages of 208, 480, and 2,400. It was reported that, for this equipment only, 480-volt is the most economical choice. As compared with 208 volts, the saving of the 480-volt installation ranges from $1 per horsepower at 100 horsepower, to $5 per horsepower at 500 horsepower, and $8 per horsepower at 1,000 horsepower. A 2,400-volt system was reported to be slightly more costly than the 480-volt system, but still cheaper than the 208-volt system in sizes of 300 horsepower and larger. However, commercial buildings frequently are located in areas in which both light and power loads are

supplied from a 208/120-volt secondary network. When the cost to the utility of supplying other than 208 volts in such areas is considered, it is shown that the over-all cost is slightly less at 208 volts unless the building has multiple vaults and a total power demand of several thousand kilovolt-amperes. Here, there may be some saving ($10 per horsepower in a typical case) by using 480 or 2,400 volts instead of 208 volts for the air conditioning motors.

This comparison is based upon providing network-class of service reliability to the air conditioning motors. If this high degree of reliability were not considered to be necessary, a simple radial system might be used. For example, the air conditioning motors might be supplied directly from a single primary feeder. When 2,400- or 4,160-volt primary feeders are available, this latter system would reflect a saving to the utility of at least $10 per kilovolt-ampere because of elimination of network transformers and protectors. When the consumer buys primary power, the situation is quite different, and a voltage higher than 208 volts can be justified even though the total building demand may be as low as 1,000 kva.

ELECTRICAL HAZARDS

"Electrical Hazards in Industry," were discussed quite informally by R. E. Stroppel (A '34) maintenance engineer for the Tool Steel Gear and Pinion Company, Cincinnati, Ohio. Mr. Stroppel has made safety his hobby, and has spoken before many engineering and civic groups on the subject, incidental to which he has inspected many plants in the Ohio area and also has worked with the National Safety Conference.

Maintenance, preventive maintenance in its fullest sense, was recommended as a most effective instrument for prevention of accidents. Temporary installations have a way of becoming permanent, with a resultant high accident rate. Electrical maintenance and repair work seldom is of a spectacular nature, and this tendency for dullness has discouraged active and effective preventive measures in many instances.

Eternal vigilence is necessary not only to keep machines and wiring systems in good order, but to instruct and to caution workers against careless familiarity in their everyday contacts with electric equipment. The formation of safety committees in plants was advocated. Extensive general discussion centered around the topic of the grounding of portable electric equipment.

The general consensus was that safety topics should be discussed more frequently and more generally at AIEE District and general meetings.

Energy Sources are Subject of Electric Power Conference

The second of a series of conferences concerning methods of producing electric power was held during the recent Midwest general meeting in Chicago, sponsored by the AIEE committee on basic sciences, and under the chairmanship of Doctor W. A. Lewis, Jr. (F '45) of the Armour Research Foundation, Chicago, Ill. The conference attracted an attendance of 80. The purpose of these conferences is to present to electrical engineers a review of the fundamental principles underlying the various methods of generating electric power, as reported by recognized authorities in the several subjects. At the first conference, which was held in New York, N. Y., during the 1947 AIEE winter meeting, conference papers were presented which described emission phenomena, piezoelectric phenomena, and electrostatic phenomena. Most of this material subsequently was published in *ELECTRICAL ENGINEERING*. At the Chicago conference, three more sources of energy were discussed, as indicated in the following paragraphs.

ELECTROCHEMICAL PHENOMENA

Under the subject title of "Electrochemical Phenomena," Doctor George W. Vinal (F '42) chief of the electrochemical section of the National Bureau of Standards, Washington, D. C., discussed electrochemical sources of electric power in general, briefly traced the history of batteries, and described recent developments. He also discussed the transformation of energy from one form into another. From early times to the end of the 18th century, knowledge of electricity developed slowly. When Volta announced his discovery of the voltaic pile in a letter to the Royal Society of London, the effect was immediate. Subsequent years solved the development of many new types of batteries. Farraday in 1833 stated his well-known laws of electrochemical action and coined the now familiar words, "electrodes," "electrolyte," "ions." In 1860, Planté utilized the effect of polarization as a means of storing electric energy. From that has come the well-known lead–acid storage battery. In the same decade, Leclanché invented a primary cell, which in its present form is known as the dry cell. Doctor Vinal reviewed the theory of batteries, discussed the related chemical reactions in some detail, and stated that the thermodynamic proof of battery theory is based upon recent determinations of the heat of reaction and on precise electrical measurements.

The chemistry of dry cells is rather more complex than that of lead–acid storage batteries, but much has been learned recently through the use of such new and powerful research tools as the electron microscope, the X-ray spectrograph, the mass spectrograph, and the petrographic microscope. Other batteries were discussed including air-depolarized cells, alkaline storage batteries, and the copper-oxide primary cell. Attention was called to the "New American Standard Specifications" for dry cells and batteries, and a comparison was made of 1946 test data with the new standard requirements. The effect of temperature on batteries is particularly important at the present time.

MAGNETOSTRICTIVE GENERATORS

Under the subject "Magnetostrictive Generators," J. A. Osborne of the Naval Research Laboratory, Washington, D. C., discussed fundamental magnetic properties of materials which give rise to magnetostrictive effects, and described several magnetostrictive devices and applications; the use of magnetostriction effect for the conversion of the chemical energy to electric energy, or conversely. These effects involve a change in the dimension of a magnetic specimen when subjected to a magnetic field, or a change in magnetic properties of that specimen when the specimen is strained mechanically. Heretofore these effects have not been used specifically for the generation of electric power. Therefore, to gain insight into these effects to see how they might be used, the author devoted considerable attention to a qualitative discussion of the fundamental mechanisms involved in magnetic and magnetostriction phenomena, including:

1. Physical properties of domains.
2. Factors determining direction of domain magnetization—magnetic, crystal, and stress energy.
3. Effect of crystal energy as shown by directions of easy and hard magnetization.
4. Description of magnetization curve in terms of domain changes.
5. Effect of stress on magnetic properties of materials having positive and negative magnetostriction (shown for nickel and 78.5 permalloy under tension).
6. Saturation magnetostriction (relative change in specimen length from demagnetized to saturated states) of iron–nickel alloys, domain interpretation of magnetization changes caused by stress.
7. Relation between magnetostriction and elastic strain, and its effect on Young's modulus.
8. Stress energy resulting from magnetostrictive strains.

Considerable attention also was given to discussing and analyzing the operation of devices which make use of the foregoing magnetostriction effects.

THERMOELECTRIC GENERATOR DESIGN

"General Considerations in Thermoelectric Generator Designs," were discussed by G. B. Ellis of the United States Army Signal Corps Engineering Laboratories at Fort Monmouth, N. J. Briefly tracing the history of thermoelectric effects back to the early part of the 18th century, the author gave particular attention to thermoelectric devices which came into use during the recent war as electric power sources which were especially attractive for their high portability, quietness of operation, pureness as a source of direct voltage, and low maintenance. Experimental work

conducted by the Army led to the development of some units utilizing chromel-constantan couples heated by wood, charcoal, or gasoline, as expedient. As crude as these were, they did indicate a definite place for such generators provided the over-all efficiency could be brought into line with portable engine-driven generators, especially in the small power range of 300 watts or lower. Present types of thermoelectric generators have a weight-to-power ratio of 2.1 pounds per watt, including gasoline fuel for eight hours of operation. Generators have been designed under this ratio having an output up to 40 watts and a maximum potential of the order of 12 volts with an over-all efficiency ranging from 0.2 per cent from liquid fuel to d-c power.

A study of the over-all concepts of thermocouple and generator design, both from the theoretical and the practical point of view, has indicated certain parameters which are believed to indicate the general physical and electrical characteristics which must be satisfied before a thermocouple may be considered seriously as an efficient source of power. Some of the most important of these points are:

1. Maximum hot-junction temperature of approximately 1,000 degrees Fahrenheit.
2. An electric potential characteristic of 600 microvolts per degree centigrade.
3. Strong mechanical structure.
4. Low internal resistance.
5. Resistance to oxidation over prolonged periods.

Observations of literature and experimental data show that such a couple has not been developed as yet. Application of quantum mechanics and a complete review of materials in the light of electron theory may result in a thermocouple, the lattice structure of which has the optimum desired characteristics. A thermoelectric generator having an efficiency in excess of 80 per cent would revolutionize conversion units in the small power field and would find a definite place for itself in the commercial and military fields of applications.

Radiations Subject of Discussion at Tuesday Session on Lighting

Some 65 persons gathered for the lighting session at Chicago, under the chairmanship of S. B. Williams (M '37) of the Sylvania Electric Products Inc., New York, N. Y. A special invitation to AIEE members to attend the Second International Lighting Exposition, then currently being held at the Hotel Stevens in Chicago, was extended by ILE Chairman E. C. Huerkamp. Also, the "Role of IES and ILE in the Lighting Industry," were described by R. W. Staud, president of the Illuminating Engineering Society and vice-chairman of the Second International Lighting Exposition.

The remainder of the session was devoted to a review of ultravisible radiations, infrared radiations, and ultraviolet radiations, in relation to the production and application of light. These subjects were discussed respectively by R. G. Slauer (A '41) manager, applications laboratory, Sylvania Electric Products Inc., Salem, Mass.; E. A. Lindsay of the General Electric Company, Schenectady, N. Y.; and C. F. Jensen of the Westinghouse Lamp Division, Chicago, Ill.

VISIBLE RADIATIONS

Mr. Slauer reported that light sources have progressed along three main lines: incandescent filament lamps, gaseous discharge lamps, and a variation of the gaseous discharge lamp that is so important that it rates a separate listing, namely, fluorescent lamps. Any evaluation of light sources for illumination purposes might recognize the limitations imposed by the human eye. Mr. Slauer's definition of light sources in this category were stated to have only one purpose—that of assisting the human eye to see. Thus, any discussion of efficiency or effectiveness must revolve around visual characteristics. Basic among these is the term "lumen," the unit of light flux, which is defined in terms of the variable average sensitivity of most human eyes between 4,000 and 7,000 angstrom units. This curve hits its peak close to the 5,500-angstrom line and reaches almost insignificance at the extreme violet and red ends of the spectrum. With the lumen as the base unit of output, it is impossible for any light source to approach an efficiency higher than about 225 lumens per watt or 35 per cent, if so-called white light is desired. This desire, of course, is challenged in such developments as the sodium lamp which owes its efficiency not to inherent conversion energy of light, but to that conversion at particularly effective wave lengths. One of the outstanding factors of the fluorescent lamp development is the fact that we may learn to modify the spectrum enough to utilize radiations which give a synthetic appearance of white and yet are so balanced as to utilize more efficient wave lengths than normal.

The incandescent lamp has been the standard light source for some 50 years, and, as viewed today, it will remain standard because of its simplicity, low initial cost, and flexibility. Technically, the development of the incandescent lamp revolves around the use of tungsten as a filament material. One may state safely at the present time that there is no indication that tungsten will be displaced, although there also is no reason to believe that techniques may not be developed which will permit tungsten to be pushed much nearer to its melting point and therefore into higher efficiency zones.

Gaseous-discharge lamps have not changed materially as most of them were introduced during the past two decades. Naturally some have been added, among these such special lamps as the zirconium lamp described in the October issue of *ELECTRICAL ENGINEERING* (*pp 975–9*) and the cesium lamp for infrared radiation. The two lamps which have received the most active commercial adaption are the mercury and the sodium. Potentially, mercury is quite efficient, especially as one is enabled to increase the pressure of the gas within which the arc operates, and this in turn provides a more satisfactory color.

The fluorescent lamp is actually an outstanding form of mercury lamp, although seldom classed as such. If it were not for this modified form of mercury lamp, it seems reasonable to assume that mercury arc lamps as such would have developed very much more rapidly during the past ten years. It should be noted that all basic light sources other than the incandescent lamp require some auxiliary operating equipment. However, the fluorescent lamp of today can be made instant starting; it can have simplified accessories; and its efficiency, even including such accessories, is somewhat higher than previous light sources so that its pattern of application is not hampered.

In all of these sources, it would be rash to say that anyone has reached its limit. Incandescent lamps seem limited to 25 lumens per watt; gaseous discharge lamps to 40–50 lumens per watt for sodium, 30–75 lumens per watt for ordinary mercury; fluorescent lamps seem to be limited to 75–100 lumens per watt. However, these are just today's viewpoint. So many factors of design are involved that the modification of any one of them instantly may change this trend in development, so that over the next 10 to 15 years we may have a reversal of emphasis just as we have had in the past 15 years.

ULTRAVIOLET RADIATIONS

Mr. Jensen in his discussion considered the range of ultraviolet radiation from 4,000 angstrom units to 2,000 angstrom units, breaking this region down into four major groups: near ultraviolet, erythemal ultraviolet, bactericidal ultraviolet, and ozone.

In the region of near ultraviolet, the uses are primarily inspection and identification. There is, however, in this region considerable interest in so-called black light effects. One of the major uses for this field is in quick inspection of incoming materials for spots, stains, and other appearance defects. A specific example would be the inspection of varnished or lacquered parts to indicate the extent of the lacquered parts. This was used extensively by transformer and electronic parts to determine the cover of the mildew-proof lacquer applied to these parts supplied to the Army and Navy during the war. Another important application in this field is inspection during or after processing of part. A specific example in this is the Zyglow process for determining cracks in materials set up during processing. A number of these strain cracks are practically invisible to the eye but are deep enough to hold a fluorescent penetrant that, when

subjected to the radiations in the black light region, fluoresce vividly thus enabling a quick rejection of these parts. Another field in this region, at the moment not too extensively explored, is the use of phosphorescent materials for the identification of switches or obstructions during the course of a power failure.

The region represented by erythemal radiation primarily is considered only for its therapeutic effects. However, recent investigations indicate that many photochemical processes can be improved, speeded up, or developed by the use of ultraviolet radiation in this field. One of the most important current investigations is in the speeding up of the process of producing insecticide by means of high intensity sources of ultraviolet in the region around 2,900 angstrom units. Another investigation in this field is that of removing scorched spots from shirts. One of the major shirt manufacturers in the country has been doing considerable experimentation and finds that it is not only possible but economical to do this.

Under the heading "bactericidal radiations" can be considered all of the person and product protection problems that all industries are faced with today. Tests have proved that by placing sterilamps in air ducts, a 99 per cent kill of all air-borne bacteria can be affected each time the air passes over the lamps. This is being used extensively in pharmaceutical houses for protection of the personnel and product being packaged. Another important application in this field is the use of either sterilamp or germicidal lamps for irradiating the upper air in offices, theaters, and other places where people congregate for any period of time. The exact percentages in this application require further test data for confirmation, but early indications are that during the winter months, particularly when the windows and doors are closed, this type of insulation can reduce cross-infection and the spread of respiratory diseases. Direct irradiation of wrappings and product practically can eliminate all of the normal contamination that is picked up in processing materials that are sensitive to such things as mold and other bacterial spoilage. This field also offers tremendous possibilities in maintaining sterile conditions of dishes, instruments, and the like. This is a field that is being investigated by the medical profession as offering another device or two by which public health and safety may be enhanced.

The ozone-producing region of ultraviolet is still open to considerable experiment, and investigation work to date indicates that this energy is largely responsible for correction of odors. However, whether this is the result of breakdown of the odor or a screening effect of the stronger odor of ozone is debatable. In the field of refrigeration the ozone energy has a tendency to reach the shaded areas and maintain the clean conditions that are desirable. This energy also produces an odor that is associated normally with cleanliness and is used for cleaning up the odors normally found in washrooms and places of that ilk.

While there is no definite source of ultraviolet energy for each individual band or region as indicated by the foregoing, there are sources that are made specifically because their major output is in one or more of the afore-mentioned regions. The entire field of energy required can be obtained by using mercury arc sources of various designs and operating pressures.

Resistance Welding Problems Discussed at Chicago Conference

The conference session on the subject of resistance welding held during the Chicago meeting under the chairmanship of E. H. Vedder (M '35) of the Westinghouse Electric Corporation, Buffalo, N. Y., was particularly notable for the two papers which related to the use of 3-phase systems of resistance welding for the purpose of reducing the over-all kilovolt-ampere demand and reducing also the flicker of lights on the same circuits. This subject involves several controversial aspects, many of which were discussed. A trend toward closer agreement on the technical facts involved seems to be under way. There seemed to be general agreement that several different methods of reducing power demand have a proper place in the picture, depending upon conditions peculiar to any particular installation. These methods include frequency converters, series-capacitor power-factor corrrection at the individual welder unit, and dry-type rectifiers. About 95 persons attended the session.

TIMING CIRCUITS

"Timing Circuits in Resistance Welding Controls" were discussed by B. Sussman of the General Electric Company, Schenectady, N. Y. This was the re-presentation of a conference paper presented in September at the Middle Eastern District meeting in Dayton, Ohio, and digested briefly in the November issue of *ELECTRICAL ENGINEERING* (*p 1142*). The author pointed out that modern high-speed welding processes require proper timing of the sequences in a welding operation, to assure high-quality weld. Electronic timing circuits can accomplish this result easily, cheaply, and accurately. These timing circuits may be used to control "squeeze time," "weld time," "hold time," and "off time," for a simple resistance spot-weld. In addition, they may consist of special timing circuits to furnish "forge-delay time," "preheating time," "post-heating time," or "tempering time." The time-delay range may vary from one cycle to several hundred cycles. Regardless of the function of the particular timing circuit involved, it was pointed out that the circuits are fundamentally the same.

BALANCED LOAD MACHINES

"Three-Phase Balanced-Load Resistance-Welding Machines," were discussed at some length by David Sciaky of Sciaky Brothers Inc., Chicago, Ill. The operation of resistance welding equipment commonly presents a serious power problem both to the equipment user and to the power supplier, because of the low-power factor (usually below 30 per cent) of such equipment and its relatively high kilovolt-ampere power demand for short intervals of time. Further, where synchronous controlling equipment is not used, transient peak values of current up to two times the intermittent load current may be drawn at the start of each weld impulse. Another factor in the operation of a single-phase welder is that as material is introduced into the throat of the machine, the secondary current decreases. To overcome these defects and to draw a balanced power from all three phases of the power supply, the Sciaky 3-phase system was developed. In this system, a direct current is supplied to the primary winding of the welding transformer, which current creates a current in the secondary winding of the welding transformer which increases exponentially during the beginning of the pulse and maintains its value for the duration of the pulse, which may be anywhere from 0.0833 to 0.2 second.

As the current in the secondary winding is unidirectional for each pulse, and as its intensity changes very little after the first 0.02 second, the effect of the reactance in the secondary winding is eliminated, and the secondary current is impeded only by the d-c resistance of the secondary circuit. As a result, the power requirement to produce the same secondary current in a 3-phase machine may be reduced to from one-fourth to one-sixth of the power required to produce an equal current in a conventional single-phase machine. Other advantages cited by the

Philip Sporn at the Tidd 500-kv test line symposium on Monday of the Midwest general meeting

author include: constant secondary current, irrespective of whether heavy steel sections are introduced into the throat of the machine; no high-current transient at the start of each impulse when using non-synchronous control equipment of 3-phase welders; reduction of supply-circuit installation costs as compared with single-phase equipment.

Also presented were "Functionalized Resistance Welding Control—Safety Features," by C. B. Stadum (A '43) of the Westinghouse Electric Corporation, Buffalo, N. Y.; and "Various Resistance-Welding Systems and Their Effect on the Power Supply," by C. E. Smith (M '44) of the Taylor-Winfield Corporation, Warren, Ohio.

Machinery Problems Discussed at Chicago

Five technical program papers giving the various aspects of problems relative to rotating electric machinery were presented and discussed at a Chicago session under the chairmanship of W. R. Hough of the Reliance Electric and Engineering Company, Cleveland, Ohio, which was attended by 35 persons.

VARIABLE-RATIO FREQUENCY CHANGER

"Suddenly Applied Loads on a Variable-Ratio Frequency Changer," were discussed in a paper by G. K. Carter (M '43) of the University of Virginia, Charlottesville, and F. J. Maginnis (A '43) and F. S. Rothe (A '36) of the General Electric Company, Schenectady, N. Y., giving the results of a differential-analyzer study which included the sudden application of load on the induction machine and the case of sudden short circuit. The study was undertaken to provide information on the ability of such a machine to maintain voltage, and on the manner of growth or decay of the load currents as determined by the magnitude and the type (3-phase or single-phase) of the load impedance, by the operating slip, and by the operation of automatic controls. The primary application of these results is as an aid in the selection of proper relaying equipment and settings, and in the understanding of the performance of such relaying. The variable-ratio frequency-changer set differs from a synchronous-synchronous tie, or from a conventional synchronous generator, in that the induction machine is self-excited; in other words, derives its excitation from the output terminals. Thus, depending upon the severity of the disturbance or the magnitude of a suddenly applied load, voltage either will be sustained at a relatively large value or will collapse completely. A comparatively small increase in load thus may produce a major change in the resulting current at a critical value, and it becomes difficult to predict the exact force of the current at values near this point.

On the basis of their analysis, the authors determined the following conclusions:

1. For the machine studied, the amount of load which can be carried without collapse of voltage is of the following order of magnitude:

Condition	Per Unit Load: Kva at Unit Voltage	Per Unit Load: Reactance on Loaded Phase
3 ϕ, 2.9 per cent slip, pomer factor field resistor short-circuited	1.33	0.75
3 ϕ, 5.9 per cent slip, pomer factor field resistor short-circuited	1.00	1.00
3 ϕ, 2.9 per cent slip, pomer factor field resistor not short-circuited	<1.00	>1.00
1 ϕ, 2.9 per cent slip, pomer factor field resistor short-circuited	2.00	0.25

2. The initial a-c decrement does not give a definite indication of whether or not voltage will be sustained.

3. While the d-c component has an exponential decay, the a-c component does not appear to exhibit definite exponential decay rates.

4. At lower slip, somewhat greater loads can be applied without causing the voltage to collapse.

5. Short-circuiting the power factor control field resistor at the instant of load application helps materially in sustaining the terminal voltage.

TENSORIAL ANALYSIS

"Tensorial Analysis and Equivalent Circuit of a Variable-Ratio Frequency Changer," were discussed by Gabriel Kron (M '45) of the General Electric Company, Schenectady, N. Y., in a companion paper to the one reported in the preceding paragraphs. Kron derives by the tensorial method the steady-state equivalent circuit and the transient equations of a variable-ratio frequency-changer set consisting of an ohmic-drop exciter, regulating machine, and induction machine, when an unbalanced load suddenly is applied to the stator side of the induction machine. The results of the solution of these equations by the a-c network analyzer and the differential analyzer, are given in the afore-mentioned companion paper.

RESYNCHRONIZING

The "Resynchronizing of Generators," was discussed in a paper by C. Concordia (F '46) and M. Temoshok of the General Electric Company, Schenectady, N. Y., on the basis of differential-analyzer studies. The design of an electric power system ordinarily involves the determination of power limits of stable generator operation, both in the steady-state and as affected by faults. In the usual stability study, the criterion of proper operation is that the generator shall not lose synchronism under the most severe fault that reasonably can be expected. However, in a condition where almost all generators are loaded to capacity, so that the loss of a single generator is to be avoided if at all possible, it becomes of interest to know whether a generator may or may not resynchronize spontaneously following a fault during which the generator has slipped one or more pole-pairs, even though with the ordinary criterion it would be considered that the system is unstable and that the generator should be tripped off the line. Two questions are then to be answered: first, how large can the system impedance be for spontaneous resynchronization; and second, if synchronism is likely to be lost, what is the best way in which to relay the machine? A related problem is the loss of field excitation, from any of various causes; and it becomes of interest to determine the machine characteristics following loss of field, with the objective of obtaining, as in the foregoing, the surest indication of when to trip the machine. On the basis of their differential-analyzing studies, the authors reported the following conclusions:

1. Resynchronization from the most unfavorable angle and with the maximum load considered is benefited largely by two factors:

(*a*). Small system impedance after the generator is cleared.

(*b*). Small inertia of turbine-generator set.

2. Other factors favoring resynchronization to some degree are

(*a*). Voltage regulator action.
(*b*). Large speed governor time constant.
(*c*). Small slip at time of fault clearing.

3. For a given system and load, resynchronization is determined principally by the machine angle at which fault clearing occurs.

4. The system reactance with which spontaneous resynchronization can occur varies from 10 per cent to 30 per cent, depending upon voltage regulator action, rotor inertia, and speed governor time lag.

5. Voltage regulator action enabled resynchronizing on a system with impedance approximately five per cent (on the machine base) larger than with no regulator action.

6. Resynchronizing from 6.9 per cent slip after 1.5 seconds of fault application occurred with the same degree of ease as resynchronizing from 2.8 per cent slip after 0.5 second.

7. Out-of-step performance of a generator on loss of field can be predicted from the steady-state slip-torque curve of the machine.

8. Distance relay settings can be determined for out-of-step operation resulting from loss of field and stator 3-phase short circuits, by viewing the equivalent generator impedance from the time of fault to the final conditions.

TWO-STAGE ROTOTROL

"Two-Stage Rototrol for Low-Energy Regulating Systems," was described by A. W. Kimball of the Westinghouse Electric Corporation, Buffalo, N. Y. For some 15 years, rotating machines have been used increasingly to perform regulating or control functions. Recently, a few applications have arisen in which the control energy available was too small to provide a satisfactory regulation through a single-stage Rototrol equipment. Consequently, a second unit, operating as a control-energy amplifier, was needed. The development of the 2-stage Rototrol permits the use of only one machine for such applications. The simplest construction of this machine is as a 4-pole design. It is actually a normal generator except for the field coils and the armature connections. In effect, this machine may be considered as three generators superimposed on each other on a single shaft.

CIRCLE DIAGRAM

In a paper "The Circle Diagram of the Polyphase Brush Shifting Commutator Motor (Schrage Type)," P. W. Franklin (A '39) of the Continental Electric Company, Newark, N. J., also presented performance and design formulas of this ma-

chine. Using assumptions similar to those required for the derivation of the Heyland circle, the author developed a simple diagram which permits the graphical determination of current, power factor, output, slip, and copper losses of the machine.

Industrial Control Problems Discussed

In a session devoted to industrial control topics, under the chairmanship of John D. Leitch (M '42) chief engineer of the Electric Controller and Manufacturing Company, Cleveland, Ohio, about 100 persons attended to audit and discuss one technical and three conference papers.

WIND-TUNNEL DRIVES

"A Control System for Wind-Tunnel Drives" was described by A. H. Heidenreich (F '27) of the National Advisory Committee for Aeronautics, Cleveland, Ohio. Most of the large wind tunnels designed for subsonic research utilize what is known as the Clymer type of drive, the principal elements of which consist of a constant-speed motor-generator set, a variable-speed motor-generator set, and a wound-rotor induction motor. The function of this drive is to provide power at variable speeds for the fans or axial-flow compressors which create the wind velocities in the tunnel. The speed range through which the drive motor must operate may be as great as 80 to 1, and the control must be able to hold any selected speed within this range constant within the limits of plus or minus 0.25 per cent of full-load speed. Extensive auxiliary equipment also is necessary to control speed, to prevent hunting, to limit the current interchange between the d-c machines of the constant-speed and of the variable-speed sets, to provide a constant direct base voltage, and to hold power factor constant. The NACA flight propulsion research laboratory in Cleveland, Ohio, utilizes the Clymer type of drive for the operation of its altitude wind tunnel. This installation represents a typical collection of the equipment involved, which includes a 4-unit constant-speed set consisting of a 4,800-kva synchronous machine and two d-c machines together with exciter; a variable-frequency motor-generator set composed of a 12,000-kva synchronous machine and two d-c machines; a main or fan-drive motor of the wound-rotor type, rated at 19,700 horsepower at a synchronous speed of 450 rpm, although the top speed required by the tunnel is 410 rpm. This is a lot of horsepower and a lot of equipment to be controlled automatically and dependably to give a final accuracy of speed control within from 0.1 to 0.25 per cent. Discussion of the paper brought out the fact that while the Clymer system is relatively expensive, it is considered by competent observers to be the electrical industry's best answer to the problem of accurate speed control of aeronautical wind tunnels.

COLOR-REGISTER CONTROL

"Modern Rotogravure Color-Register Control Systems" were discussed in considerable detail by G. B. Dunn of the General Electric Company. The author described the operation of various electronic and related devices designed to keep the fast-moving paper actually in position as it passes through the various color stages of a printing press, and thus insure that each successive color imprinted will be accurately in register.

MINE HOIST CONTROL

"Some Present-Day Practices in A-C Mine Hoist Control" were reviewed by J. W. Cooke and G. W. Heumann (M '46) of the General Electric Company, Schenectady, N. Y. Although special conditions sometimes warrant the use of d-c motors with adjustable-voltage control for mine hoists, a-c induction motors and their associated controls have been developed to the point where they provide adequate and economical operation of somewhere between 90 and 95 per cent of the hundreds of mine hoists which have been installed in mining camps throughout the world in recent years. These installations range in size from 50 to 3,500 horsepower.

Primary control generally is effected by having the primary winding of the hoist motor controlled magnetically by reversing contactors. Magnetic control offers the advantage that safety interlocks can be wired directly into the magnetic control circuits, thus removing power automatically in cases of abnormal operating conditions such as over-speed or over-travel of the skip. Mine hoist motors ranging in size from 50 to a few hundred horsepower in most instances are low voltage—600 volts or less. The primary control of such motors includes air-brake reversing contactors, of conventional low-voltage design. Such contactors are electrically and mechanically interlocked. Hoist motors ranging from a few hundred horsepower to several thousand horsepower normally are wound for use on 2,400- or 4,160-volt power supply lines. Years of experience have proved that the primary windings of such motors can be controlled best by air-brake high-voltage contactors equipped with magnetic blowouts.

Secondary control commonly is effected on small and infrequently operated hoists through summary-magnetic devices. Contactors control the motor primary and a drum-switch commutates the secondary resistor sections. For larger and more frequently operated hoists, full magnetic control has come to be used commonly in recent years, employing secondary contactors and resistors, and supplanting the old liquid rheostat and very large drum switches.

D-c dynamic braking control has been used successfully on a number of unbalanced slope hoists. In this system, d-c excitation is applied to the stator windings of the hoist motor. When direct current is applied to the stator of an induction motor, a stationary flux is set up in the air gap. When the rotor is turned by an overhauling load, an electromotive force is induced in the rotor, and current flows in the secondary circuit, the motor acting as an alternator. The motor speed can be varied by adjusting the amount of secondary resistance through which the kinetic energy of the hoist load is dissipated. The retardation of balanced hoists often is accomplished by "plugging" the motor. Retardation thus is obtained by electric means which saves wear on the brakes. Mine hoist installations also incorporate certain accessories, such as over-wind limit switches, brake wear limit switches, brake solenoids, and other devices affording protection to personnel and equipment.

ELECTROLYTIC PROCESSES

In a paper entitled "An Electronic Regulator for Electrolytic Processes," W. F. Gerdes of the General Electric Company, describes one of the numerous methods of obtaining the regulation required for electrochemical processes.

F. H. Lane (right), general chairman of the general meeting committee for the Midwest general meeting, and AIEE President B. D. Hull study the week's program

Transmission, Transformers, and Grounding Subject of Session on Wednesday

The AIEE committee report, "Present-Day Grounding Practices on Power Systems," was the highlight of a session on transmission, transformer, and grounding problems, presided over by G. B. Dodds (M '45) of the Duquesne Light Company, Pittsburgh, Pa., and attended by 120 persons. The AIEE committee on present-day grounding practices prepared this report from replies to questionnaires submitted to public and private utilities in the United States and Canada having a generating capacity of more than 10,000 kw, or having more than 10,000 customers. The report covers separately the grounding practices on generating stations and on transmission and distribution systems. Its scope is indicated by the fact that the information on generating stations was drawn from 460 systems operating at 11 kv and above (involving 33,752 megavolt-amperes' in generating capacity in 972 generating units), and the grounding data on transmission and distribution systems was drawn from 567 systems operating at 22 kv and above (involving 119,081 miles of transmission and distribution circuits). These figures denote that information was obtained on about three-fourths of the facilities existing in the classes investigated. The report has been printed in the form of AIEE technical paper 47-237, and is available from AIEE headquarters, 33 West 39th Street, New York 18, N. Y., at 40 cents per copy to members, 75 cents per copy to nonmembers.

SWITCHING SURGES

In a paper entitled "Switching High-Voltage Transmission Lines," I. B. Johnson (M '45) and J. R. Wilson of the General Electric Company, Schenectady, N. Y., presented results and conclusions drawn from a study of switching surges, including the effects of line voltage and length, and the characteristics of lightning arresters, circuit breakers, and the system in general. This report covered a transient-analyzer study, and indicated the practicality and effectiveness of using a representation in miniature for the study of related phenomena involving voltage arresters and switching surges.

GASEOUS INSULATION

In a paper entitled "Gaseous Insulation for High-Voltage Apparatus," G. Camilli (F '43) and J. J. Chapman (A '40) of the General Electric Company, Pittsfield, Mass., reported the results of an investigation made to determine the impulse and 60-cycle strength of a group of halogenated gaseous compounds in uniform and non-uniform fields at pressures of one, two, and three atmospheres. The scope of the investigation was confined to bare electrodes, and additional testing will be required to determine the behavior of these gases with various types of solid insulation. The authors reported that sulphur hexafluoride (SF_6) possesses superior insulating properties for high-voltage apparatus, even at these relatively low pressures; qualities superior to the Freons. Data obtained in an approximately uniform field indicate that at 30 pounds gauge pressure, this gas approaches the impulse strength of oil. Therefore, certain classes of high-voltage apparatus may make advantageous use of this gas for insulation, if other properties are adequate. Important advantages of gaseous insulation over liquid and solid insulation were enumerated:

1. By using sufficient pressure, the dielectric strength of some gases may rival that of mineral oil. SF_6 accomplishes this at a lower pressure than any other gas explored so far.

2. SF_6 and other gases in general are not subject to permanent cumulative breakdown as is solid insulation.

3. SF_6 is stable at high temperatures. More important, is the fact that it is noninflammable.

4. Gases are generally self-healing after breakdown except where a creepage path over solid insulation is involved. If the composition of the gas results in a carbon deposit, a permanent type of defect remains. This does not apply to SF_6, because no carbon is contained in a molecular structure.

TRANSIENT VOLTAGE RISE

A report on results of an investigation of "Transient Voltage Rise in Transformers Due to Interruption of Exciting Current," were reported by A. Srinivasan of the Allis-Chalmers Manufacturing Company, Pittsburgh, Pa., and F. J. Vogel (M '41) of the Illinois Institute of Technology, Chicago, Ill. The magnitude of the voltage induced in the winding of a transformer by the sudden interruption of the transformer magnetizing current may be several times the normal voltage to ground, and, unless adequate insulation is provided, may cause insulation failure. The authors reported voltages as high as seven times normal under such conditions. As the rise in voltage is fixed by the effective capacitance, it appears that the smaller the capacitance, the greater will be the voltage rise. Hence, a set of external capacitances connected to the terminals of the transformers will increase the effective capacitance and thereby reduce the voltage rise. As the voltage rise is caused by the change of flux in the iron, it should result in uniform distribution through the winding. Most switching surges result from flux linking windings and hence the authors conclude that switching surges are likely to be distributed uniformly in windings.

SWITCHGEAR CONTROL

"The Application of Storage Batteries to the Control of Switchgear" was the subject of a technical paper by E. A. Hoxie (A '45) of the Electric Storage Battery Company, Philadelphia, Pa. Standard control voltages for closing and tripping electrically operated circuit breakers are defined in the National Electrical Manufacturers Association and the American Standards Association Standards: that the operating voltage ranges of circuit breaker closing and tripping mechanisms, which normally are rated at 125 volts direct current, are from 90 to 130 volts for closing, and from 70 to 140 volts for tripping. Voltage limitations of indicating-lamp assemblies, and the coils of relays and control devices also limit the voltage of the control bus to a maximum of 140. However, it has been pointed out in some instances that the minimum voltage of 90 referred to in the NEMA and ASA Standards is not sufficient to obtain proper operation under adverse operating conditions.

On the basis of actual test results, the author reported the following findings:

1. The voltage at the battery terminals that is available for closing circuit breakers under normal operating conditions, with the charging equipment in operation, is appreciably higher than the voltage at the battery at the end of a continuous 1-minute discharge; the actual value being influenced considerably by the voltage at the battery terminals at the beginning of load application. It appears that the minimum voltage from a fully charged battery, on open circuit with reference to charging equipment, while discharging into a circuit breaker closing mechanism, at the battery's 1-minute current discharge rate to 1.75 volts per cell, may be considered as being 107 volts after several successive circuit breaker closing operations.

2. Additional voltage at the closing mechanisms may be obtained from the control battery by increasing the number of cells in the battery to more than 60, but if this is done, means will have to be provided to prevent over-voltage damage to other equipment connected to the control bus. One method of accomplishing this is to add end cells to the battery beyond the point at which the auxiliary equipment is supplied, the higher voltage to be applied only to the circuits feeding the circuit breaker operating mechanisms.

3. Additional voltage at the closing mechanism may be obtained by using control batteries of larger capacity, but this method requires excessive increase in battery capacity (up to 300 per cent) unless it is possible to restrict the voltage drop in the control wiring to five volts or less.

4. The operating voltage range of from 90 to 130 for closing d-c operated circuit breakers from a nominally rated 125-volt control bus may be reduced from the existing standard; an operating voltage range of from 100 to 120 is suggested as a possibility.

5. The adoption of a smaller operating voltage range would make possible the design of circuit-breaker closing mechanisms capable of providing adequate power under all operating conditions. If this were done, no change would be required in the present method of selecting batteries.

GENERAL DISCUSSION

In a discussion of the Johnson-Wilson presentation, P. L. Bellaschi (F '40) formerly of the Westinghouse Electric Corporation, stated that in many years of practical experience and observations, he had found that on systems having a solidly grounded neutral, a figure of three times normal voltage for the switching surge would represent a good average figure to use when considering switching surges.

A discussion on gaseous insulation submitted by G. C. Nonken (M '45) of the General Electric Company, Pittsfield, Mass., showed the relationship between molecular weight and pressure at which dielectric strength decreases, and pointed

out that SF_6 does not begin to decrease in dielectric strength until pressure is appreciably higher than the critical pressure for several other gases.

In a discussion on the report of present-day grounding practices, V. J. Cissna (M '30) of the Tennessee Valley Authority, Chattanooga, Tenn., took exception to the present recommended use of X_0/X_1 and R_0/X_1 ratios as the criteria for determining the degree of neutral grounding. He pointed out that curves were in use which assumed resistance to be negligible, and which therefore are not generally applicable and should not be applied in instances where appreciable resistance is present. Examples were given indicating that under certain conditions over-voltage would be indicated by the use of the present curves dealing with X_0/X_1 and R_0/X_1 whereas actually no over-voltage would be present. The discusser suggested that an effectively grounded system should be described by the voltage rise on unfaulted conductors during a line-to-ground fault, and that the amount of permitted rise should be agreed upon.

W. R. Brownlee (M '38) and J. A. Elzi (M '38), both of Commonwealth and Southern Corporation, Jackson, Mich., submitted a discussion in which they called attention to conflicting objectives in determining the amount of impedance, if any, to use in generator grounding. For example, adequate surge protection may conflict with prevention of mechanical damage to generator windings from large fault currents. They questioned the conclusion that the emphasis on generator system grounding should be placed on reducing large value of fault current, pointing out that the objective of "limitation of damage" can be obtained by rapid clearance of faults if sufficient fault current is available to cause operation of protective relays.

Wiring Report Described at Industrial Power Session

Highlight of the industrial power systems session at the recent AIEE Midwest general meeting in Chicago, was the presentation of the "First Interim Report on Interior Wiring Design for Commercial Buildings." The report was prepared by the AIEE subcommittee on interior wiring design for commercial buildings under the chairmanship of Benjamin F. Thomas, Jr. (M '29) chief electrical and mechanical engineer of the New York, N. Y., consulting engineering firm of Moran, Proctor, Freeman, and Mueser.

Mr. Thomas traced the project back to the 1937 "Handbook on Interior Wiring Design," produced by the joint industry committee on interior wiring design and issued to a total of some 47,000 copies. Subsequently, revision of this handbook was undertaken by the industry committee and, in October 1945, two pamphlets were issued, one relating to the wiring of residences and the other to the wiring of farm buildings. Prior to issuance of these pamphlets, the industry committee requested the AIEE to prepare a report on the interior wiring of commercial buildings.

The Institute was not then, nor is it now, a sponsor of the industry committee, although many individual members of that committee were members of the Institute. In 1944, the AIEE agreed to undertake preparation of this report, which will be issued as an AIEE publication. The work was referred to the industrial applications committee which, in the fall of 1946, organized this subcommittee on the subject of interior wiring design for commercial buildings. Subsequently, the subcommittee on commercial wiring practices of the AIEE committee on domestic and commercial applications was merged with the wiring design subcommittee. By November 1946 the working program for the project was established and a means was arranged for representation of the subcommittee from various sections of the United States to insure that the practices, rules, and regulations of each section of the nation be given consideration in the final report. To accomplish this objective, ten members were appointed from ten different cities, and each was requested to form in his city a group of electrical engineers interested in the subject, to participate actively in the project by discussing and criticizing drafts of the report as submitted, and also to offer suggestions as to subject to be covered and the best method of presenting the data.

The contemplated final report will be divided into two major parts, the first part covering general design which is applicable in whole or in part to all types of buildings. The purpose of this section will be to discuss the basic principles of wiring design and explain what is necessary for an adequate wiring system, and the reasons therefore. The second section of the report is planned to cover the various classifications of buildings, and will bring out the particular and the special problems of design for each class. Work on the second section of the report is not expected to be started until the first section has been completed.

It was the first section of the report, in incomplete and preliminary form, which was presented at the Chicago conference for discussion. The scope of the report is indicated by its chapter headings:

1. Survey of requirements.
2. General requirements for interior wiring systems
3. Design of secondary distribution systems.
4. Design of primary distribution systems.
5. Electrical services.
6. Generating plants as a part of commercial buildings.
7. Communication and signaling systems.
8. Special conditions.
9. Grounding practices.

Not all of these chapters were present in the preliminary report discussed at Chicago, as chapters 3, 4, 6, and 8 have not been prepared as yet.

The purpose of the report is to present an outline of the method of procedure for the application of sound engineering principles to the design of the interior wiring systems for commercial buildings. It is not to be a textbook on wiring, or a wiring code. Neither is it to be a typical set of specifications. Rather, it is to be an explanation of *what* to do and *why*, when undertaking the design of a wiring system The methods of accomplishing the desired ends will be treated only for special conditions, as this information is available in most handbooks and textbooks on wiring. The committee believed that it should stress the "what to do and why," and go lightly on the "how."

Copies of this interim report currently are available from AIEE headquarters, identified as AIEE miscellaneous paper 47-249, available to members at 40 cents per copy and to nonmembers at 70 cents per copy. The committee is anxious for the report to be reviewed and criticized as widely and as promptly as possible so that its work may progress without delay, and with the benefit of wide comment and suggestion, for its proposed ultimate reports and recommendations.

Solar Radiation Studies Reported at Chicago Session

The basic sciences session, one of the terminal sessions of the Chicago meeting, was presided over by Chairman J. D. Tebo (M '36) of the AIEE basic sciences committee. Attendance was about 60 persons.

HISTORY

"A Brief History of Studies in Solar Radiation," was given by Doctor J. T. Wilson of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Scientists have discovered that the ionized layer of atmosphere above the earth's surface, which acts as a radio reflector, is like a giant latticework which changes in accordance with the amount of solar radiation it receives. They have shown that when radiation intensities are low, the latticework expands and permits the reflection of longer wave lengths to take place efficiently, while shorter wave lengths seem to penetrate the ionized layer and are lost in space. When solar radiation intensity increases, the latticework closes, and shorter wave lengths are reflected more efficiently. With this knowledge, it becomes possible to predict the most desirable frequency for radio broadcasts at any particular time which will be reflected from the ionized layer back to the earth and be receivable most effectively at some remote point.

Such observations also have shown that the sun itself is a source of radio signals, and that when certain classes of disturbances are taking place on or near the surface of the sun, a radio signal extending from 50 to 200 megacycles occasionally may be received here upon the earth. Through the use of an instrument called the "coronagraph," which is a type of telescopic camera which produces an artifical eclipse of the sun every day, it has been possible to study the sun's corona and permanences daily.

Thus it becomes possible to predict when solar radiation will cause detectable magnetic disturbances here upon the earth. Such magnetic disturbances often affect telegraphic communications and, in some instances, are of sufficiently great amplitude to cause peculiar behavior in long distance electric power transmission lines. With the increasing numbers of installations of large electric generating plants on the larger rivers of the United States, the science of predicting magnetic disturbances and the changes in the electric potential of the ground becomes of increasing importance.

CIRCUIT CALCULATIONS

"Ignitor Characteristic and Circuit Calculations," were described and explained in some detail by D. E. Marshall (M'33) of the Westinghouse Electric Corporation, Bloomfield, N. J. An ignitron is a gas electronic tube whose cathode is a pool of liquid mercury. In operation, electrons are emitted from the mercury pool and move to the anode. Their motion constitutes an electric current. The action, however, is not self-starting. The conduction is started by means of a rod of material, called the ignitor, of resistivity high compared with the mercury, one end of which is submerged into the mercury pool. When a current is passed through this rod, the arc will start at the junction of the mercury surface and the resistance rod. If such a tube is connected in series with a source of alternating voltage and a suitable impedance, the arc can be made to start whenever the anode is more than a few volts positive, and is extinguished automatically at the end of each positive half cycle. Therefore, control of the phase of starting of the arc is possible. The tube then has properties similar to those of a thyratron with the advantages of the high electron emission and long life properties of the mercury pool.

The current required to start the ignitor and the resistance of the ignitor must be known so that circuits can be designed which will fire the ignitor reliably. In certain instances, such as resistance welding control, the load impedance is in series with the ignitor. The characteristic of the ignitor then limits the minimum loading which the tube will control satisfactorily. The firing current and voltage of an ignitor varies as a function of the constants of the circuit through which it is fired.

Problems exist in describing the characteristics of the ignitors of these tubes in such a manner that the data can be used in a practical way in estimating their performance under a particular set of circuit conditions. Of interest to the circuit designer are questions pertaining to the power required to drive the ignitor, the current and voltage rating of ignitor driving equipment, the energy expended, and other similar factors. These quantities may be calculated or estimated by the usual methods if the wave form, voltage, and current of the ignitor firing pulse are known. The authors' discussions on calculations are intended to contribute to the solution of these problems.

Doctor Enrico Fermi discusses the "Future Prospects of Atomic Energy" at the Midwest meeting's general session on Tuesday

CORONA STARTING VOLTAGES

"Determination of Corona Starting Voltages for Nonuniform Fields in Air," were discussed at some length by J. G. Hutton of the General Electric Company, Schenectady, N. Y. Until recently, sparkover and corona starting voltages could be predetermined satisfactorily only in instances where experimental curves or empirical formulas were available. The advent of the Townsend theory, and later its modification, led to a general method in breakdown calculations, although these were not entirely successful until a more complete knowledge of the Townsend coefficients for air was obtained. Based upon this knowledge, and from published data, Ver Planck developed a method especially applicable for calculating initial breakdown voltages for nonuniform fields which converge toward the cathode; this was reported in AIEE *TRANSACTIONS* in 1931. Although still empirical, the increased data enabled more accurate results to be obtained from this method. Mr. Hutton's objective is to apply the theory to a case where the field is produced between a flat plate and an edge formed by two intersecting planes, and to verify the results experimentally, which he did.

DIFFUSION OF CURRENT

"Diffusion of Electric Current into Rods, Tubes, and Flat Surfaces," was discussed by K. W. Miller (M'29) of the Armour Research Foundation, Illinois Institute of Technology, Chicago. Doctor Miller's primary purpose was to show that skin effect is the result of a true diffusion type of penetration of current density as it "soaks" into the conductor, starting from the surface of the conductor during current transients in a manner physically and mathematically analogous to thermal diffusion in transient heat flow. The author stated that this useful concept is used to explain physically and to evaluate numerically the transient resistance and inductance of conductors subjected to rectangular current-wave impulses.

Power Generation Session Tells of Progress and Probability

A session at the Chicago meeting was devoted to the subject of power generation, under the chairmanship of A. H. Frampton (F'45) of the Hydro-Electric Power Commission of Ontario, Toronto, Canada. The attendance was about 170.

POWER PROGRESS

"Progress in Power Generation, 1940–46" was reported upon by the AIEE power generation committee. Outstanding achievement on the home front during World War II was the production of electric energy by the central station utilities. From a total generation of 127,642 million kilowatt-hours in 1939, the output rose to a peak in 1944 of 229,766 million kilowatt-hours. Comparable capacities were 38,862,000 kw in 1939 (excluding the New York City Transit System plants) and 49,799,000 kw in 1944. Thus, there was an 80 per cent increase in output with only a 27 per cent increase in capacity. Estimates have indicated that war needs took about 1 per cent of electric energy output in 1939, 42 per cent in 1944. Over-all capacity factors increased from 37.5 per cent in 1939 to 52.9 per cent in 1944, while the composite utilization factor increased from 72.8 to 82.5 per cent for the same two years, indicating a considerable decrease in reserve capacity.

Throughout these years, the proportion of hydroelectric capacity and generation has remained practically constant when compared with the total power production activity, the per cent of total capacity ranging from 27.5 to 29.6, and the per cent of total generation ranging from 30.4 to 36.0. Of the 3,700,000-kw increase in hydroelectric generating capacity between 1940 and 1946, about 3,300,000 kw was installed by governmental power districts. Governmental agencies and municipalities own and operate about 20 per cent of the total generating capacity in the United States, this factor including all types of prime movers.

The most amazing aspect of the power demand picture has been the rapid rise in load, nation-wide, since the summer of 1946, the increase being about 20 per cent. Various estimates indicate that the total capacity, central station and industrial, steam and hydroelectric, to be installed within the next three years will be in excess of 12,000,000 kw.

Utilization of Diesel engines during the war increased many times, most applications being in the transportation field, on land and sea. The largest installation of internal-combustion engines embraced 68 units totaling 78,000 kw capacity installed in 1942–43 for an aluminum reduction plant at Jones Mills, Ark. The installation consisted of 18 2,250-kw dual-fuel Diesel

engines and 50 750-kw convertible gas engines. These engines supplied two aluminum pot-lines having a peak demand of 67,000 kw and an annual load factor of 94 per cent.

Since 1939, considerable progress has been realized in the development of the gas turbine as a prime power producer. Many schemes have been proposed and are under experimentation for practical gas-turbine cycle arrangements. Two gas-turbine locomotives, designed for pulverized coal burning with ash separation, now are under construction in the United States for the Locomotive Development Committee of Bituminous Research, Inc.

The first serious attempt at the generating of electric energy on a commercial scale from the wind as a source of power was made during this period. The first unit went on test October 1941, and by February 1943 had operated on the line for 695 hours and off the line on test for 192 hours, generating a total of 298,240 kilowatt-hours. A redesigned 1,500-kw wind turbine will be erected on a high summit in the Green Mountains of Vermont, again to feed into a utility system. Wind-power plants always must operate in parallel with another source of power. Studies indicate that in any one year, a wind-power plant can generate more kilowatt-hours than most water-power plants, because average wind conditions remain more stable from year to year than do average weather conditions. Large-scale release of energy from the atomic nucleus is the outstanding scientific achievement realized during World War II. This new means of energy production places itself squarely in the field of power generation for possible future utilization. However, the radioactive features of this process impose formidible problems of control, design, and waste disposal, which long may delay practical economic applications to power production. In contrast to the unfortunate popular furor produced by irresponsible prognosticators, stands the fact that atomic energy is not synonymous with free energy. Heavy investments are required, with consequent heavy fixed charges. One published estimate states that atomic plants of 500,000-kw capacity and greater, appear likely to produce electric energy at a cost competitive with steam-electric or hydroelectric energy. Obviously, the economic opportunity to apply plants of this size will be rare at the present time.

PAPERS PRESENTED

Four technical program papers reflecting the practices, procedures, and experiences of four different operating companies in the application of the theory of probability to the determination of required reserve capacity were presented at this same session:

1. "Generating Reserve Capacity Determined by the Probability Method," by Giuseppe Calabrese (M '40) of the Consolidated Edison Company, New York, N. Y.

2. "Calculating Probability of Generating Capacity Outages," by W. J. Lyman (F '43) of the Duquesne Light Company, Pittsburgh, Pa.

3. "Outage Expectancy as a Basis for Generator Reserve," by H. P. Seelye (F '43) The Detroit Edison Company, Detroit, Mich.

4. "Probability Methods Applied to Generating Capacity Problems of a Combined Hydro and Steam System," by E. S. Loane and C. W. Watchorn (A '29) of the Pennsylvania Water and Power Company, Baltimore, Md.

Session Devoted to Storage Battery Maintenance

A conference session in Chicago devoted to the subject of care and maintenance of storage batteries, under the chairmanship of H. C. Riggs (A '42) of the Electric Storage Battery Company, Philadelphia, Pa., was given over to the presentation and discussion of one technical program paper and two conference papers.

BATTERIES IN A STEEL PLANT

"The Care and Maintenance of Storage Batteries in a Steel Plant" was discussed in a conference paper by V. E. Schlossberg (M '35) of the Inland Steel Company, East Chicago, Ind. The care and maintenance of storage batteries in a steel plant in general, amounts to the addition of approved water, maintaining the battery in a healthy state of charge without excessive overcharging, keeping the battery clean outside, and avoiding damaging high temperatures. The actual care of the battery is not the entire problem in a large installation. Consideration must be given also to the number of battery charges per truck per day, the truck time lost in charging batteries, safety to the truck operator and the battery service men, as well as to the loading of the charging equipment. The problem involves the standardization of battery sizes so that batteries are interchangeable among a group of trucks. It also involves the selection of appropriate charging equipment and a battery-station arrangement which requires the least amount of personnel attention. In short, the battery service must fit in with, and be a part of, the materials-handling installation.

BATTERIES ON RAILROADS

"The Care and Maintenance of Storage Batteries on Railroads" was discussed by R. I. Fort of the Illinois Central Railroad.

Among the many factors affecting storage batteries, peculiar to railroad operation, the author laid particular stress upon the great increase in the total electric load in the modern railroad car. Within the past 15 years the connected load per car has grown from about 1 kw to as much as 25 kw per car, and to 45 kw in dining cars with electric ranges. The earlier railroad practice of providing a storage battery sufficiently large to carry the car load for eight hours no longer is possible because of the weight and space limitations. Consequently, many cars now have no more than two hours capacity. Also, the movement of cars from point to point daily necessitates a system for insuring consistent maintenance regardless of location in the individual car. This maintenance routine is built around a record card carried in each car, on which space is provided for necessary historical information and to which is added the daily record of work performed. Vertical space limitation restricts the room for reaching rear cells of the battery for maintenance. The development of a roll-out battery cradle whereby the entire battery may be rolled out from under the car, and then locked back into position, offers a solution to this problem.

The yard charging of batteries, although not desirable, frequently is necessary, and entails considerable investment in equipment. For example, one large railroad has some 400 charging receptacles at 32 different points on its system, each with associated a-c–d-c conversion equipment, controls, and distribution wiring. In addition, that same railroad has some 15 portable charging sets each capable of handling from 1 to 4 cars.

The adjustment of generator regulators is of vital importance, as a very small variation in voltage setting will result in harmful under-charging or disastrous over-charging. Considerable attention now is being given to the development of automatic temperature compensation of the voltage adjustments. Batteries are operated in ambient temperatures which range from below zero to around 125 degrees Fahrenheit, and these extremes may be met within one day's time. Many other storage batteries are used on railroads, such as for Diesel locomotives, material-handling equipment, and other such installations, but these do not represent as many difficulties as do the car batteries. In summing up, the authors stated that "the development of a d-c transformer, or better still an a-c storage battery, would help the railroads tremendously, but in the meantime the maintenance of batteries boils down to three main essentials: keep them clean, keep the solution at the proper level, keep the rate of charge within closely controlled limits."

Wilfred Sykes, speaker at the Thursday general session of the Midwest general meeting on "Problems of the Steel Industry"

Changes in Prize Awards Announced For Technical Papers

After several years study, which included a broad cross section of views and discussion at the conference of vice-presidents and District secretaries, held during the summer general meeting in Montreal, Quebec, Canada, June 9–13, 1947, a special committee on award of Institute prizes recommended changes in the prizes for technical papers, which were approved by the board of directors, August 11, 1947, to become effective January 1, 1948.

Ultimately, all prizes will be awarded on the basis of papers presented during the administrative year, August 1–July 31. To effect the transition, all prizes for best paper and initial paper, which were presented during the calendar year 1947, will be awarded on the basis of the old rules, pamphlet on "National and District Prizes," edition of January 1941. As the prizes for Branch paper were on the basis of the academic year, July 1–June 30, they easily can be shifted to the new basis. The new rules are as follows.

PRIZES FOR TECHNICAL PAPERS

The AIEE has established a series of prizes which are available for annual award, in order that proper recognition be given its members for outstanding papers presented at its meetings and to encourage its younger members to participate in technical meetings. Each prize consists of a certificate of award and a sum of money in cash. Appropriate recognition will be given in *ELECTRICAL ENGINEERING* and in the AIEE Year Book. In the event of joint authorship the cash awards will be divided and a certificate will be issued to each author.

To compete for these awards requires only that the author (or one of the co-authors) be an *eligible member* of the Institute, a Fellow, Member, Associate, or Student member in good standing, and that the paper be presented at a *qualified technical meeting* of the AIEE, the Institute winter, summer, Midwest, or Pacific general meetings; District meetings; Section (including technical group and Subsection) meetings; or Branch meetings.

The prizes available are divided into two general classes, the first group for papers selected from among those presented by any eligible member of the Institute, the second group restricted to undergraduate Student members. These prizes and the conditions of award are summarized in this item.

In addition to the prize competitions described herein, the Districts or Sections may elect to hold other competitions. These will be arranged locally to be appropriate to the conditions obtaining in the particular District or Section and, therefore, are not covered in detail in this issue. Where such competitions are handled on an annual basis in general conformity with the procedures outlined herein for Institute Prizes, District Branch competition prize, and Branch prize, the appropriate officers of the District or Section may arrange with the Institute secretary to issue suitable cerificates of award.

INSTITUTE PRIZES

These consist of a certificate of award and $100 in cash. A single paper may be awarded one or more prizes. Honorable mention may be made of papers which do not receive prize awards.

Appropriate recognition will be given authors of prize-winning papers in the AIEE Year Book and in *ELECTRICAL ENGINEERING* including publication if the papers have not previously been published therein.

Institute prizes available are

1. *Best Paper Prize.* For the best original paper presented at any qualified technical meeting by an eligible member in each of four classes: design, operation, research, education and general interest.

2. *Branch Paper Prize.* For the best paper based upon undergraduate work presented at a Branch or other Student meeting of the Institute by a Student Member of the AIEE.

Presentations will be made annually at the regular winter general meeting.

Papers considered for the awards in any one year will be limited to those presented during the administrative year ending the preceding July 31, except as follows:

When in the opinion of the committee on award of Institute prizes the number of papers in a given class is not sufficient to constitute a real competition the award may be withheld. In this case these papers will be considered with others presented in the following year.

All papers approved by the technical program committee which are presented at the winter, summer, Midwest, or Pacific general meetings of the Institute or District meetings will be considered for best paper prizes without other formal offering in competition. All other papers presented at District, Section, Branch, or Student meetings will be considered, if submitted in triplicate to the Institute secretary before September 15 of the following administrative year and accompanied by a written statement as to when and where the papers were presented. This may be done by officers of the Institute, by the officers of geographical Districts or Sections, or by authors.

Institute prize awards will be made by a committee known as the committee on award of Institute prizes which consists of the chairman of the technical program committee, acting as chairman; the chairmen of the publication committee, the committee on research, and the technical program committee of the previous year; and the chairmen of such other committees as the board of directors may designate.

The committee on award of Institute prizes has the assistance of the technical program committee which grades papers at the time they initially are reviewed for acceptance, and may suggest the class under which the papers are to be considered.

DISTRICT BRANCH COMPETITION PRIZE

A District Branch competition prize is available for award during each of the administrative years ending July 31, in each of the geographical Districts of the Institute for the best paper prepared by an undergraduate Student Member and presented orally by the author at a District competition open to student representatives of the Branches within the District. These prizes consist of a certificate of award issued by the officers of the District and $25 in cash.

Papers presented orally also would be eligible for the Institute Branch paper prize, but for this purpose would need to be submitted in the form of a written paper as described under "Institute Prizes."

The District Branch competition prize will be awarded by the District executive committee or by special committees appointed by the District executive committee. The award will be made at the conference or meeting at which the papers are presented. The District secretary informs the Institute secretary of the title, name of author or coauthors, and date and place of presentation of the prize-winning paper so that suitable certificates may be engrossed. The award made by each District will be announced annually at the winter general meeting of the Institute at the time the Institute prizes are presented.

BRANCH PRIZE

This prize is available for award annually during the administrative year ending July 31 to an undergraduate Student Member who is the winner of an oral or oral and written competition in the Branch with which he is associated, held to select a Branch representative for entry in a District Branch competition. The prize consists of a certificate of award, the sum of $10 plus an allowance of seven cents per mile one way to the District competition.

In a year when a District Branch competition is not held, the award may be made for a competition within the Branch but the traveling allowance will not be made.

Oral presentations are eligible for the Institute Branch paper prize, but for this purpose the subject matter must be submitted subsequently in the form of a written paper as described under "Institute Prizes."

The Student Branch counselor informs the Institute secretary of the title, name of author or coauthors, and date and place of presentation of the prize-winning paper so that suitable certificates may be engrossed.

BASIS OF GRADING FOR BEST PAPER PRIZES

The valuations which govern the grading of papers for the purpose of awarding best paper prizes are

Analysis of Subject. The paper should present a clear outline of the situation out of which arises the need for the preparation of a paper on the particular

subject, explaining the point-of-view assumed in the presentation. (15 per cent)

Logical Presentation. The presentation should include an analysis of the difficulties encountered, methods of attack, and solution of problem. (15 per cent)

Originality. Credit should be given to the paper which brings to its subject matter a fresh point of view a healthy open-mindedness, or a discarding of some outworn traditions. (15 per cent)

Unity. While brevity and conciseness are important, they should not be attained at the sacrifice of unity and completeness of presentation. (15 per cent)

Value in Electrical Engineering Field. The value of the paper as a contribution to the literature in the electrical engineering field should receive particular consideration. (40 per cent)

BASIS OF GRADING FOR DISTRICT BRANCH COMPETITION AND BRANCH PAPER PRIZES

As the objective of student papers differs from that of adult papers, the basis of grading given in the following has been adopted. It is not the primary purpose of student papers to contribute to the technical advancement of the profession; they should constitute a vehicle for the training and stimulation of future contributors to the profession. To this end greater emphasis has been placed on written presentation and the exercise of engineering thinking than on technical value.

Content

Originality. Exercise of thought and imagination must accompany the engineer's work. While laboratory research is not required, there should be clear evidence of the author's own thinking. (20 per cent)

Survey of Subject (Analytical Procedure). The breakdown of the problem into its parts, their study, and assembly from the fundamental laws of nature characterize the engineering way of attack. (15 per cent)

Importance. In engineering, potential usefulness is important. Evidence of good reason for considering the subject treated in the paper should be made clear. (15 per cent)

Written Presentation

Appropriateness. The paper should be appropriate to the audience for which it is written. (10 per cent)

Mode of Expression.

(a). Logical organization of material for clarity, forcefulness, and interest. Appropriate headings are essential. (10 per cent)

(b). Concise and coherent expression of thoughts in good English and with proper choice of words. (10 per cent)

(c). Effective and judicious use of pictorial and graphical presentation. (10 per cent)

Adequate Introduction and Closure. The background for the paper should be clear, and results or conclusions should be well summarized. (10 per cent)

BASIS OF GRADING FOR ORAL PRESENTATION

Grading for oral presentation is based on:

Speaking Technique. The speaker should be easy and natural, speaking clearly with a pleasing quality. His manner should be self-possessed. A reasonable use of notes is preferable to memorizing or reading. (35 per cent)

Style—Organization of Material. Logical organization of material for clarity, forcefulness, and interest to show alert thinking and incite thinking of audience. Concise and coherent expression in good English with proper choice of words. Proper proportioning of introduction, body, and conclusion. (35 per cent)

Introduction and Conclusion. Proper address to chair and audience. Background for the paper should be clear and the results or conclusion well summarized. (15 per cent)

Discussion. Speaker should show reasonable familiarity with his subject, answering questions wisely without losing his poise. (15 per cent)

If circumstances are such as to make desirable temporary modifications in the awarding of prizes, the board of directors, at its discretion, may make whatever changes appear necessary. They will be effective for the administrative year following that in which they are announced in *ELECTRICAL ENGINEERING.*

Conference on Electron Tubes Scheduled for Philadelphia

A conference on special electron tubes for use in electronic instruments is being sponsored by the AIEE subcommittee on electronic instruments, which is a joint subcommittee under the electronics committee and the committee on instruments and measurements. This committee, feeling that there was a need in the instrument field for tubes having special characteristics, principally longer life and closer tolerances on the important electrical characteristics, has conducted a survey of the instrument manufacturers, industrial laboratories, and others interested in a special tube program. The survey has shown that a considerable demand for such tubes exists and indicated the characteristics and tolerances which were thought desirable.

The conference will bring together representatives of instrument manufacturers, tube manufacturers, and engineers from industrial, commercial, and academic laboratories, and the AIEE survey will be presented along with a tentative list of special tubes with their characteristics prepared by the committee. Tube manufacturers representatives will discuss the feasibility of such a program and representatives of instrument manufacturers will present their problems and views. There will be ample opportunity for general discussion from the floor by those attending. In addition there will be a dinner for all conferees with a program of special interest, including a speaker prominent in the electrical field.

The conference is to be held at the Benjamin Franklin Hotel in Philadelphia, Pa., March 29, 30, and 31, 1948. There will be no registration fee for AIEE mem-

Mexican Market Place

This busy market scene is characteristic of the colorful spectacles which attract the visitor to the city of Mexico, Mexico, where the 1948 AIEE summer general meeting will be held

bers but a fee will be charged all nonmembers except enrolled Students and the immediate families of members. Advance registration will be required. Invitations will be sent out in February. Requests for invitations are invited and should be addressed to C. C. Wilson, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. A preprint of the committee report on the special tube survey, including the AIEE tentative list of special tubes and their characteristics, will be available in advance of the conference. This may be ordered at the time of registration. A transcription of the proceedings of the conference will be published and offered for sale after the Philadelphia meeting.

The committee believes that the special tube program will be a significant contribution to the electronic instrument field and urges participation of all those interested to insure the widest possible field of use for any special tubes which may be made available as a result.

Personnel Announced for Basic Sciences Subcommittee

The following is a list of the names of the several members of the subcommittees of the AIEE committee on basic sciences. These names have been released since the official list of officers and committees was published (*EE, Oct '47, 1031–8*).

Subcommittee on Energy Sources:

W. A. Lewis, *chairman*	Walther Richter
W. C. Brown	J. J. Smith
R. C. Hanna	B. R. Teare
L. W. Matsch	J. D. Tebo

Subcommittee on Applied Mathematics:

M. G. Malti, *chairman* — Henry B. Hansteen
Harry Sohon

Subcommittee on Large Scale Computing Devices:

C. Concordia, *chairman*	W. C. Johnson
J. G. Brainerd	G. D. McCann
S. H. Caldwell	J. C. McPherson
E. L. Harder	J. D. Tebo

Subcommittee on Electric Circuit Theory:

J. G. Brainerd, *chairman*	F. J. Maginniss
R. L. Dietzold	W. O. Osbon
E. A. Guillemin	E. B. Payne
T. J. Higgins	W. E. Phillips

Basic Sciences Officers. J. D. Tebo, chairman of the committee on basic sciences, has announced that N. S. Hibshman, dean, school of engineering, Pratt Institute, Brooklyn, N. Y., has been appointed secretary of the committee. K. W. Miller, assistant director, Armour Research Foundation, Technology Center, Chicago, Ill., is the new vice-chairman.

Publication Available on Electric Conversion Equipment

"Application of Electric Conversion Equipment to the Electrochemical Industry," a publication sponsored jointly by the AIEE committees on electrochemistry and electrometallurgy and electronic power converter, covers the broad aspects of the use of modern mercury arc rectifier conversion equipment in the zinc, magnesium, chlorine, aluminum, copper, and the mining and smelting industries.

Included in the publication are:

Large Rectifier Station Practice (*EE, Oct '47, pp 957–63*)

D-C Power for the Chlorine-Caustic Industry, M. S. Kircher, D. O. Hubbard (*EE, Nov '47, pp 1059–63*)

D-C Power for Magnesium Plants, F. S. Glaza (*EE, Nov '47, pp 1063–8*)

Conversion Equipment in the United States Aluminum Industry, Joel Tompkins (*EE, Nov '47, pp 1068–73*)

Paralleling Rectifiers and Converters, R. J. Kennard (*EE, Nov '47, pp 1074–6*)

Conversion Equipment in the du Pont Company, Harold E. Houck (*EE, Nov '47, pp 1077–82*)

The publication is available from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y. The price is 80 cents (40 cents to AIEE members).

Report Submitted on Polarity of D-C Control

At the Standards committee meeting of June 11, 1947, in Montreal, Quebec, Canada, a report was submitted by the AIEE committee on automatic stations. This report represented an analysis and summation of the results of a widely circulated questionnaire on control connections, in which the committee recommended standardization on negative polarity connection of d-c control coils.

After a discussion of the report, the Standards committee took action which is summarized in the following paragraph covering the recommended practice:

Suggested text for a "Standard Clause on Coil Corrosion Prevention" (for insertion in Standards on power circuit breakers, switchgear assemblies, industrial control equipment, railway control equipment, transformers and feeder regulators, relays used with power switchgear, and automatic stations).

Polarity of device coil connections. Where such coils are operated from d-c supply and when de-energized are not disconnected from both the positive and negative supply leads, it is recommended that the connections be such as to leave the coils permanently connected to the negative supply lead to minimize the possibility of corrosion of the coil or its leads.

PERSONAL . . . . .

H. A. Triplett (A '18, M '21) formerly chief engineer, Schweitzer and Conrad, Inc., Chicago, Ill., has been placed in charge of engineering for the A. B. Chance Company's, Centralia, Mo., line of power switching equipment, and **B. O. Watkins** (A '43, M '46) formerly senior engineer, Rural Electrification Administration, Washington, D. C., has been appointed construction and maintenance equipment engineer of the A. B. Chance Company, Centralia, Mo.

I. F. Baker (M '19) formerly assistant to the president, Westinghouse Electric International Company, New York, N. Y., recently was elected vice-president of that company. Mr. Baker has been with the Westinghouse Electric Company since 1909.

P. R. Kendall (A '42) formerly communications engineer, Belmont Radio Corporation, Chicago, Ill., has been appointed regional sales manager of the New York territory of Motorola, Inc.

Earle Wild (A '27, M '36) formerly assistant chief load dispatcher, Commonwealth Edison Company, Chicago, Ill., has been appointed chief load dispatcher of that company. **R. T. Purdy** (A '40) operating department of the Commonwealth Edison Company, Chicago, Ill., has been appointed assistant chief load dispatcher in Mr. Wild's place.

R. R. Robley (A '18, F '45) assistant to president, Portland (Oreg.) General Electric Company; **G. E. Quinan** (A '18, F '18) chief consulting engineer, Puget Sound Power and Light Company, Seattle, Wash.; **A. M. Chitty** (M '22) Manager, Southern Division, Puget Sound Power and Light Company, Olympia, Wash.; and **F. H. Murphy** (A '07, F '30) consulting engineer, Portland (Oreg.) General Electric Company, were among the 13 Northwestern pioneers in the electric industry at the Northwest Electric Light and Power Association's annual meeting in Vancouver, British Columbia, Canada, who were awarded honorary life membership in the association.

J. P. Lewis (A '32, M '42) formerly assistant to the manager, Connecticut Power Company, Stamford, has been appointed director of engineering in that company.

K. L. Partridge (A '25, M '44) formerly distribution engineer, Hartford (Conn.) Electric Light Company, recently was appointed assistant superintendent of engineering in the engineering department of that organization.

B. Z. Segall (A '43) formerly electric distribution engineer, New Orleans (La.) Public Service, Inc., has been appointed executive vice-president and chief engineer of the Best Electric Company, Inc., New Orleans, La.

C. S. Thorn (M '34) previously first vice-president and general manager, Birmingham (Ala.) Electric Company, has been elected president of that company. Mr. Thorn is an electrical engineering graduate of Rensselaer Polytechnic Institute. He became affiliated with the Birmingham Electric Company in 1927.

Rudolf Feldt (M '46) engineer, head of applications engineering department, Allen B. DuMont Laboratories, Inc., Passaic,

N. J., has been appointed head of the cathode-ray oscillograph manufacturing department with headquarters in the Clifton, N. J., plant. He has been with the company since 1935.

C. B. Jolliffe (M '34) executive vice-president, in charge of RCA laboratories, Radio Corporation of America, Princeton, N. J., has been elected to the board of directors of that company. Dr. Jolliffe joined the Radio Corporation of America in 1935 as engineer-in-charge of the RCA frequency bureau. He became executive vice-president in 1945.

Philip Sporn (A '20, F '30) recently elected president of the American Gas and Electric Company, New York, N. Y., also has been elected president of the Atlantic City Electric Company, Atlantic City, N. J.

R. C. Mason (A '26, M '37) who has been on leave of absence from the atomic energy project in Oak Ridge, Tenn., for the past year, has been appointed manager of the electro-physics department of the Westinghouse Research Laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa. He succeeds **G. W. Penney** (A '26, F '45) who recently was appointed Westinghouse professor of electrical engineering at the Carnegie Institute of Technology, Pittsburgh, Pa.

W. L. Emery (A '37, M '46) formerly a member of the electrical engineering department Iowa State College, Ames, has been appointed associate professor of electrical engineering at the University of Utah, Salt Lake City. Doctor Emery assumed his duties with the autumn quarter.

J. W. Cook (A '26) construction engineer, Achison, Topeka, and Santa Fe Railway Company, Topeka, Kans., was a member of an American Commission of Communication Experts which recently left for Colombia, South America, at the invitation of that country's government.

D. B. Hoseason (A '22, M '28) formerly director, Falcon Works, Rush Electrical Engineering Company, Ltd., Loughborough, England, recently was appointed director of studies at the Administrative Staff College, Henly-on-Thames. Mr. Hoseason also has been elected vice-president of the Institution of Electrical Engineers.

L. M. Goldsmith (F'47) chief engineer, Atlantic Refining Company, Philadelphia, Pa., has received the War Department's decoration "for exceptional service with the Office of the Chief of Engineers during World War II. His outstanding performance in co-ordinating specifications for and procuring pumping equipment and lead cable essential to installing a petroleum pipeline across the English Channel contributed to the successful prosecution of the war."

W. J. D. Geary (A '27) formerly superintendent of operation, Pennsylvania Power and Light Company, Hazleton, has been promoted to the position of general superintendent for that company.

G. A. Drewett (M '42) previously district engineer, engineering department, Northwestern Electric Company, Vancouver, Wash., has been appointed superintendent of construction for the Pacific Power and Light Company, with headquarters in Portland, Oreg., as a result of the merger of the Pacific Power and Light Company and Northwestern Electric Company. **E. F. Pearson** (M '20, F '37) formerly assistant to vice-president and general manager, Northwestern Electric Company, Portland, Oreg., has been appointed assistant general manager of the northwestern division of the Pacific Power and Light Company, in charge of operations in Portland and Rainier, Oreg., and Vancouver and Camas, Wash. **H. H. Schoolfield** (M '18, F '40) previously general superintendent, engineering and construction department, Pacific Power and Light Company, Portland, Oreg., has been named chief engineer of the combined companies, and **O. L. LeFever** (A '10, F '44) formerly chief engineer of Northwestern's engineering section has been made assistant chief engineer of the companies. **Tom Perry** (A '21) formerly assistant general superintendent, plant department, Northwestern Electric Company, in Portland, Oreg., has been appointed superintendent of the northwestern division of these merged organizations.

R. C. Crouse (M '45) formerly airway engineer, Civil Aeronautics Administration, Washington, D. C., has been named chief of the Maintenance Division Plant and Structures branch, for the Sixth Region of the Administration.

B. S. Rodey, Jr. (A '22, M '26) formerly associate controller, Consolidated Edison Company of New York (N. Y.) Inc., has been elected an assistant secretary of the company. Mr. Rodey has been with the Consolidated Edison System since 1921.

A. W. Milliken (A '30) vice-president and newly elected member of the board of directors, New York State Electric and Gas Corporation, Ithaca, has been placed in charge of technical operations for that company. **D. A. Lewis** (M '35) manager of the eastern division of that same company, will go to Binghamton as assistant to Mr. Milliken.

C. E. Bragunier (A '37, M '45) formerly associated with Ebasco Service, Inc., New York, N. Y., as an electrical engineer, has joined Westcott and Mapes, Inc., architects and engineers of New Haven, Conn., in the capacity of electrical engineer. He will be responsible for the design work on generating plants, substations, transmission lines, and other electrical problems.

H. S. Osborne (A '10, F '21) chief engineer, American Telephone and Telegraph Company, New York, N. Y., and past president of the AIEE, recently was initiated into Tau Beta Pi, the national engineering honorary society, during the society's 42d convention held at the Hotel New Yorker in New York, N. Y., from October 9 to 11, 1947. Others also initiated included **Carl Whitmore** (A '18) president, New York (N. Y.) Telephone Company; **H. R. Searing** (A '20, F '30) executive vice-president, Consolidated Edison Company of New York (N. Y.) Inc.; and **R. M. Gates** (M '35) president, The Air Preheater Corporation, New York, N. Y.

M. M. Cory (A '15, F '40) professor of electrical engineering, Michigan State College, East Lansing, has been elected national president of the engineering honorary society, Tau Beta Pi, for the year 1948. Other officers elected included **E. R. Moore** (M '40) budget engineer, system engineering department, The Detroit (Mich.) Edison Company, as vice-president of the society; and **H. M. Merker** (A '36) sales engineer, The Detroit (Mich.) Edison Company, as one of the three councillors.

J. E. Shepherd (M '44) research engineer, Sperry Gyroscope Company, Inc., Great Neck, N. Y., has been elected a director-at-large of the Institute of Radio Engineers for the 1948–50 term. Elected as IRE regional directors for 1948–49 were **H. J. Reich** (A '32, M '43) professor of electrical engineering, Dunham Laboratory, Yale University, New Haven, Conn., for region 1, the North Atlantic Region; **J. V. L. Hogan** (A '11, M '20) president of Radio Inventions, Inc., and of Faximile, Inc., New York, N. Y., for region 2, the North Central Atlantic Region; **J. B. Coleman** (A '25) assistant director of engineering of the RCA division, Radio Corporation of America, Camden, N. J., for region 3, the Central Atlantic Region; and **F. E. Terman** (A '23, F '45) dean of the school of engineering, Stanford University, Calif., for region 7, the Pacific Region.

J. R. Giantvalley (A '47) formerly a member of the editorial staff of *ELECTRICAL ENGINEERING*, now is a research laboratory analyst, Ryan Aeronautical Company, San Diego, Calif. Mr. Giantvalley is a graduate of the University of Minnesota. During the war he served as a lieutenant (junior grade) in the United States Navy.

C. W. Green (A '10, F '40) assistant to the executive vice-president and military relations personnel office, Bell Telephone Laboratories, Inc., New York, N. Y., has retired after 28 years of service with that firm. Mr. Green was graduated from the University of Wisconsin in 1907 with a bachelor of science degree. He was an instructor and assistant professor at the Massachusetts Institute of Technology, Cambridge, until the first World War,

and after the war became affiliated with the Bell system.

W. H. Martin (A '14, F '30) formerly assistant director of apparatus development, Bell Telephone Laboratories, Inc., New York, N. Y., has been made director of apparatus development-II, as a result of a division of apparatus development work of the laboratories into two general departments. Mr. Martin also will have a general responsibility for the work of the quality assurance department.

R. S. Hoyt (A '12, M '13) transmission engineering department, Bell Telephone Laboratories, Inc., New York, N. Y., has retired after 40 years of service with that company. He was graduated from the University of Wisconsin in 1905 with a bachelor of science degree in electrical engineering, and then spent a year at the Massachusetts Institute of Technology as a graduate student and assistant instructor. He joined the engineering department of the American Telephone and Telegraph Company in Boston, Mass., in 1906, and in 1907 was affiliated with the Western Electric Company, New York, N. Y. He left their employ to attend Princeton University where he obtained his master of science degree in 1910, returning to the Western Electric Company, New York, N. Y.

E. V. Stuart (A '40) general foreman, transmission lines, Public Service Company of Colorado, Denver, received the Matthews Valor Award for heading a crew of 12 which prevented the destruction of a major transmission line at Hagerman Pass, Colo., during a severe blizzard last January.

S. F. High (A '24, M '30) president of the G. W. Sullivan Electric Company, Cincinnati, Ohio, has been elected president of the National Industrial Service Association, Inc.

J. A. Robinson (A '43) formerly sales engineer, the General Electric Company, San Francisco, Calif., has joined the staff of *Electrical West*, San Francisco, Calif., as an assistant editor.

E. P. LaBelle (M '35) formerly general plant manager, British Columbia Telephone Company, Vancouver, British Columbia, Canada, has retired.

J. P. Carty (A '41) formerly general inspector, traffic department, Western Union Telegraph Company, Philadelphia, Pa., has been appointed general supervisor of testing and regulating. Mr. Carty joined the company in 1917, as an assistant automatic chief, becoming automatic chief in 1923, division traffic inspector in 1929, and general inspector in 1936.

C. T. Eyford (M '44) formerly distribution engineer, British Columbia Electric Railway Company, Ltd., Vancouver, has been appointed assistant superintendent of the transmission department, engineering division.

T. E. Roach (A '45) for the past five years vice-president and general manager of the Northwestern Electric Company, Portland, Oreg., has been elected to the position of executive vice-president and general manager of the Idaho Power Company's division at Boise.

E. M. Williams (A '40) associate professor of electrical engineering at the Carnegie Institute of Technology, Pittsburgh, Pa., has been awarded the President's Certificate of Merit for "outstanding fidelity and meritorious conduct in aid of the war effort, World War II." Doctor Williams was awarded recognition for his services as chief of the equipment development branch, special projects laboratory, engineering division, Air Technical Service Command, Wright Field, Dayton, Ohio, from 1943 to 1945.

G. D. Montgomery (A '32, M '38) formerly staff supervisor in the general plant office of the American Telephone and Telegraph Company, New York, N. Y., has transferred to the plant results section of the operation and engineering department in that company.

A. R. Gruehr (M '30) division engineer of the electrical engineering section of the Consolidated Edison Company of New York (N. Y.) Inc., now temporarily working in the rate engineer's department, has been elected president of the New York County chapter of the Society of Professional Engineers.

W. R. Harmer (A '37, M '44) formerly departmental engineer, Hydro-Electric Power Commission of Ontario, Canada, has been appointed assistant director of the consumer service division. He has been affiliated with the commission since 1939.

W. L. Barrow (M '33) formerly research director, fire control research, Sperry Gyroscope Company, Inc., Garden City, N. Y., has been appointed chief engineer of the Sperry Gyroscope Company, Inc., at Great Neck, N. Y.

R. W. Shoemaker (A '07, F '41) for the past 13 years consulting engineer for Chase Brass and Copper Company, Inc., Waterbury, Conn., and the Kennecott Wire and Cable Company, Providence, R. I., now has established his own consulting engineering office in Oakland, Calif.

G. B. Thomas (A '10, M '16) personnel director, Bell Telephone Laboratories, Inc., New York, N. Y., has retired from that post after 30 years of service with the Bell System. He has served as personnel director since the Laboratories were incorporated in 1925. Mr. Thomas was graduated from Ohio State University in 1907 with a degree in both mechanical and electrical engineering. He is currently president of the Ohio Society of New York, and is a member of the American Society for Engineering Education, American Management Association, and of the Silver Bay Industrial Conference Committee.

H. W. Russell (A '36) chief physicist of the Battelle Memorial Institute, Columbus, Ohio, since 1929, has been appointed as one of the six new assistant directors of that institute.

Grote Reber (A '44) radio engineer, Stewart Warner Corporation, Chicago, Ill., has been appointed to the staff of the National Bureau of Standards. His work will involve supervision of projects aimed at extending present knowledge of conditions indirectly affecting radio communication, and he is supervising the erection of a German Giant Wurzburg, an extremely large and powerful radar device.

H. A. Frey (A '28, M '43) previously research and development engineer, Locke Insulator Corporation, Baltimore, Md., has been appointed chief development engineer of that company. Mr. Frey has been associated with the Locke Insulator Corporation since 1926.

H. O. Hill (A '23) assistant chief engineer, fabricated steel construction department, Bethlehem (Pa.) Steel Company, recently was elected president of the American Welding Society for the year 1947–8. He assumed that office on October 24 at the conclusion of the 1947 annual meeting of the society in Chicago. Born in Ontario, Canada, Mr. Hill was educated at the University of Toronto, from which he received a bachelor of science degree in mechanical engineering. He joined the Riter-Conley Company, Pittsburgh, Pa., in 1915, and in 1916, when that company was merged into the McClintic-Marshall Company, he was serving in the capacity of chief engineer. He became assistant chief engineer of the enlarged company, and in 1931, when the McClintic-Marshall Company was merged with the Bethlehem Steel Company, he continued his same duties with the new organization. Among the societies of which Mr. Hill is a member are the American Society for Testing Materials, the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the American War Works Association. He is a registered professional engineer in the state of Pennsylvania, and a past president of the Bethlehem Rotary Club.

V. R. Tate (A '28, M '38) executive vice-president, secretary, and attorney, Perfex

R. S. Kersh

Bern Dibner

F. S. Campbell

Corporation, Milwaukee, Wis., has been elected president of the Engineers' Society of Milwaukee for a one year term. Mr. Tate was graduated from the Milwaukee School of Engineering in 1927 with a bachelor of science degree in electrical engineering. He also attended the Minnesota College of Law and was admitted to practice before the Patent Office in 1934, and later admitted to the bar. He joined the Perfex Corporation in 1934 as an engineer and patent attorney, and was elected secretary of that organization in 1936, a director in 1941, a vice-president in 1943, and executive vice-president early in 1947. Mr. Tate is also a member of the American Bar Association, the American Patent Law Association, and was chairman of the committee on incorporation of the Wisconsin Society of Professional Engineers.

W. A. Marrison (A '26, M '41) research department, Bell Telephone Laboratories, Inc., New York, N. Y., has been awarded the British Horological Institute's Gold Medal for 1947 in recognition of pioneer researches in the development of the quartz crystal clock. The medal is the institute's highest award and it was presented to Mr. Marrison at the 89th annual general meeting of the institute in London, England, on October 29. A native of Kingston, Ontario, Canada, Mr. Marrison received a bachelor of science degree from Queens University, Kingston, in 1920, and a master of science degree from Harvard University in 1921. He has been associated with the Bell Laboratories since that time, working largely on problems of frequency standardization and time. Mr. Marrison holds the grade of fellow in the American Association for the Advancement of Science, and is a member of the Optical Society of America, the Institute of Radio Engineers, the Franklin Institute, the American Physical Society, and of the New York Electrical Society.

G. W. Vinal (M '19, F '42) physicist, chief of the section of electrochemistry, National Bureau of Standards, Washington, D. C., has been awarded the Certificate of Commendation by the Bureau of Ships of the Navy Department. The certificate was granted for outstanding service to the United States Navy during World War II in the development of new types of batteries, and for Doctor Vinal's work with the joint Army–Navy Battery Advisory Committee, of which he was secretary. He received a bachelor of science degree from Wesleyan University in 1906, a master of science degree in physics in 1909, and an honorary doctorate of science in 1936. Doctor Vinal joined the staff of the National Bureau of Standards in Washington, D. C., in 1908, and since 1918 has been chief of the electrochemistry section. He has contributed extensively to scientific journals in the fields of electrochemistry, and was awarded the Gaston Plante Medal of the Societe Francaise des Electriciens in 1937. He is chairman of the battery committee of the Electrochemical Society, chairman of the dry battery and storage battery committees of the American Standards Association, and a fellow of the American Association for the Advancement of Science. He is also a member of the Washington Academy of Science, the Philosophical Society of Washington, and of Phi Beta Kappa.

H. C. Rentschler (M '40) director of lamp research, Westinghouse Electric Corporation, Bloomfield, N. J. has retired. Born on March 26, 1881, he received a bachleor of arts degree in 1903 and a master of arts degree in 1904 from Princeton University, and a doctor of philosophy degree in 1908 from John Hopkins University. From 1904 to 1905 Mr. Rentschler was an instructor in physics at Princeton (N. J.) University, and from 1908 to 1917 he was an associate professor of physics at the University of Missouri, Columbia. He joined the Westinghouse Electric Corporation in 1917. Mr. Rentschler is a member of the American Physical Society, the American Optical Society, the American Association for the Advancement of Science, and of Sigma Xi. He served on the AIEE committees of application of electricity to therapeutics from 1942 to 1946, and on the committee on electronics from 1942 to 1943.

A. M. Unger (A '40) development engineer, Pullman Standard Car Manufacturing Company, Chicago, Ill., is the author of the paper winning the fourth railroad classificational award of $1,300. This design-for-progress award program is sponsored by the James F. Lincoln Arc Welding Foundation in Cleveland, Ohio. Mr. Unger attended the University of Colorado, from which he was graduated in 1929 with honors and a bachelor of science degree in electrical engineering. In the $200,000 industrial award program sponsored by the Foundation in 1942, he and a collaborator won the first classificational award of $3,700 in the railroad division. Mr. Unger is a member of Tau Beta Pi, Eta Kappa Nu, and of the American Welding Society. During 1941–42 he was chairman of the Chicago section of the American Welding Society, and at the present time he is a representative of that society on the Chicago Technical Societies Council.

B. E. Shackelford (A '19, M '42) manager, license department of RCA international division, Radio Corporation of America, New York, N. Y., has been elected president of the Institute of Radio Engineers for the year 1948 (*p 1263*). Doctor Shackelford has been a fellow of that institute since 1938. A graduate of the University of Missouri, he received his bachelor of arts degree in 1912 and his master of arts degree in 1913. In 1916 he received his doctor of philosophy degree from the University of Chicago, and afterwards joined the staff of the Westinghouse Lamp Company, Bloomfield, N. J. He became manager of the radio engineering department in 1925, and stayed with that concern until 1930 when he became affiliated with the manufacturing department, radiotron division, of the Radio Corporation of America at Harrison, N. J. He was appointed manager of the patent department in 1934, and after serving as manager of the company's foreign license service, Doctor Shackelford transferred to New York where he became assistant to the director of research and later to the chief engineer. In 1942, he was appointed engineer-in-charge of RCA's frequency bureau, and since 1944 he has been assistant to the vice-president in charge of the RCA Laboratories, and manager of the license department of the RCA international division. Doctor Shackelford is a member of the American Physical Society, the Optical Society of America, the Franklin Institute, the American Association for the Advancement of Science, Sigma Xi, Gamma Alpha, and of Alpha Chi Sigma.

Vincent Melanchthon Montsinger (A '14, M '24, F '29) research engineer, power transformer engineering department, General Electric Company, Pittsfield, Mass., has been appointed chairman of the Lamme Medal committee of the AIEE for the year 1947–48 to replace Doctor William Elgin Wickenden, deceased. Born in High Point, N. C., on April 2, 1884, Mr. Montsinger was graduated from the Uni-

versity of North Carolina in 1909 with a bachelor of science degree in electrical engineering. He joined the General Electric Company's testing department in 1910, and in 1911 was placed in charge of the experimental testing department. He was in the designing section of that concern from 1912 to 1919 when he was advanced to the position of development engineer. After 1922 his work mainly was concerned with the general supervision of heating and insulation instructions for the design of large power transformers. Mr. Montsinger has served on various committees of the AIEE, including the Standards committee from 1928 to 1947, chairman, 1936–38; electric machinery from 1926 to 1943, chairman, 1934–36; technical program from 1934 to 1939; transformer for 1948; and the Lamme Medal committee since 1945. He was a representative of the AIEE on the Standards Council of the American Standards Association from 1937 to 1939; Electrical Standards Committee of the American Standards Association from 1937 to 1944; and on the United States National Committee of the International Electrotechnical Commission from 1937 to 1944.

F. S. Campbell (A '45) formerly manager of the Hartford (Conn.) Steam Boiler Inspection and Insurance Company's New York, N. Y., office, has been named vice-president to be in charge of the agency department for that concern. Born in Axtell, Nebr., on April 16, 1904, Mr. Campbell was graduated from the University of Nebraska in 1926 with a bachelor of science degree in electrical engineering. He then joined the student course of the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation), Pittsburgh, Pa., and after completing that was associated with the company's East Pittsburgh, South Philadelphia, and Chicago offices as a sales engineer in the application of generating equipment. In 1933 Mr. Campbell associated himself with the Hartford Steam Boiler Inspection and Insurance Company's Chicago, Ill., office as a special agent in the application of insurance and engineering inspection service. He was transferred to the Pittsburgh, Pa., office in the capacity of manager in 1944, and in 1945 was made manager of the company's Philadelphia, Pa., office. He was given charge of the company's office in New York in 1946.

J. P. Maxfield (M '23, F '27) acoustic products development group, apparatus development department, Bell Telephone Laboratories, Inc., New York, N. Y., has retired after 31 years of service with that concern. Born in 1887 in San Francisco, Calif., he later received a bachelor of science degree in electrochemistry from the Massachusetts Institute of Technology. From 1910 to 1912 Mr. Maxfield was an assistant instructor in electrochemistry at the Massachusetts Institute of Technology, Cambridge, and then was promoted to an instructor of physics at that institute. He resigned in 1914 to accept a position as research physicist with the Western Electric Company, Inc., New York, N. Y. In 1917 Mr. Maxfield was made research physicist, head of the department in charge of fundamental study of microphone contact, and in 1919 he was promoted to development engineer and head of the department in charge of fundamental development of loud-speaking systems and allied problems. In 1926 Mr. Maxfield accepted a position as manager of development and research with the Victor Talking Machine Company Camden, N. J., leaving that concern in 1929 to return to the Bell System to join Electrical Research Products, Inc. He served as director of commercial engineering of that branch from 1936 to 1942 when he returned to the Bell Laboratories as a physicist. Later in 1942 he was granted a leave to become director of the National Defense Research Council division of physical research at Duke University, Durham, N. C. He then returned to the laboratories of the Bell Telephone System in 1944 to accept the position which he held at the time of his retirement. Mr. Maxfield served on the AIEE air transportation committee in 1940–41, and he is also a member of the American Physical Society.

J. B. Whitehead (A '00, F '12) retired, professor of electrical engineering, Johns Hopkins University, Baltimore, Md., past president of the AIEE (1933–34) and Edison Medalist for 1941, has been honored by Johns Hopkins University by being the first living person to have a building at the university named for him (*page 1269*). Doctor Whitehead, a graduate of that institution, was one of the pioneers in the development of the school of engineering at the university, and is engaged actively in research as professor emeritus of electrical engineering there. He has been teaching at the university since 1898 when he was appointed an instructor in electricity. Doctor Whitehead was appointed professor of electrical engineering in 1910, the post which he held until his retirement in 1942. From 1920 to 1938 he served as dean of the school of engineering, and from 1938 to 1942 as director of the school.

F. E. Bodine (A '43) formerly sales manager of the Westinghouse Electric Corporation's San Francisco, Calif., offices, has been advanced to the position of Pacific Coast manager of maintenance sales for that concern. Mr. Bodine has been with the corporation for 21 years, and in his new capacity will serve the company's entire Pacific Coast district, plus Alaska and Hawaii.

H. E. Becker (A '37, M '23) formerly Pacific Coast supervisor, maintenance division, Westinghouse Electric Corporation, San Francisco, Calif., recently resigned to enter the contracting business.

H. M. Tilson (M '37) formerly electrical engineer, Associated Electrical Construction Corporation, San Francisco, Calif., has joined the Haynes Electric Company, Oakland, Calif., as an electrical engineer.

J. D. Frantz (A '38, M '42) formerly assistant superintendent, underground department, Northwestern Electric Company, Portland, Oreg., has been promoted to superintendent, underground department, Pacific Power and Light Company, as a result of the merger of these two companies. Mr. Frantz has been associated with the Northwestern Electric Company since 1933.

G. A. Waters (A '09, F '21) formerly chief engineer, electrical division, engineering department, Wagner Electric Corporation, St. Louis, Mo., is now vice-president in charge of manufacturing for that concern. **C. P. Potter** (A '19, F '29) previously chief engineer, electrical engineering division of the same company, succeeds Mr. Waters as chief engineer of the electrical division.

G. H. Woodard (M '42) formerly manager, aviation gas turbine division, Westinghouse Electric Corporation, Philadelphia, Pa., has entered private practice as a consulting engineer. He is affiliated with the Charles H. Welling and Company, Inc., New York, N. Y.

J. M. Cage (M '44) formerly manager of industrial electronics, Raytheon Manu-

V. M. Montsinger

H. O. Hill

W. A. Marrison

facturing Company, Waltham, Mass., recently joined the teaching staff of the school of electrical engineering at Purdue University, Lafayette, Ind., as professor of electrical engineering in charge of electronics.

F. E. Wood (M '41) formerly plant engineer, California Institute of Technology, Pasadena, Calif., has accepted a position with the Western Gypsum Company's new plant at Sigurd, Utah. He will serve as chief engineer and mechanical-electrical superintendent for this plant which will be the largest producer of Keene's cement, plaster, and plasterboard in the West.

J. O. Lang (A '43) formerly assistant supervisor, testing department, Dayton (Ohio) Power and Light Company, has been appointed supervisor of the testing department of that company. In this position Mr. Lang will have direct supervision of the testing of all electric equipment in generating stations and substations. He has been associated with the Dayton Power and Light Company since 1919.

I. F. Kinnard (A '21, F '43) formerly executive engineer, West Lynn (Mass.) Works, General Electric Company, has been appointed manager of engineering with that company. Mr. Kinnard became affiliated with the General Electric Company in 1923 when he joined the meter and instrument engineering division at West Lynn. **E. H. Howell** (A '42) formerly manager of the meter and instrument division, apparatus department, West Lynn (Mass.) Works, General Electric Company, has been appointed manager of sales with the same concern. Mr. Howell has been with General Electric since 1922, when he joined the company's student training course at Schenectady, N. Y., after graduating from the Georgia School of Technology with a degree in electrical engineering.

O. G. Thompson (A '43) branch manager, General Electric Supply Corporation, San Diego, Calif., has been elected president of the Bureau of Radio and Electrical Appliances in San Diego. For the past two years he has headed the advertising and sales promotion committee of the bureau.

Bern Dibner (A '23, F '42) previously vice-president, Burndy Engineering Company, Inc., New York, N. Y., has been elected president of that company by the board of directors. Mr. Dibner, a graduate electrical engineer, founded the Burndy organization in 1924, following his association with the Adirondack Power and Light Corporation, and the Electric Bond and Share Company. **Marvin Lee** (A '35, M '41) formerly chief engineer, Burndy Engineering Company, Inc., has been elected executive vice-president of that organization. Mr. Lee, an electrical engineer, joined the Burndy Company 23 years ago, serving as chief engineer for the greater part of that time, and as acting general manager during the war.

R. S. Kersh (A '42, M '45) branch manager of the Westinghouse Electric Corporation's Houston, Tex., office since 1942, has been named manager of industrial sales for that concern. Mr. Kersh will be located at the Westinghouse East Pittsburgh, Pa., plant. He is a graduate engineer and has spent his entire business career with the Westinghouse Corporation.

G. E. Conn, Jr. (A '40) formerly a salesman in the Philadelphia, Pa., district office of the Allis-Chalmers Company, has been named manager of the newly established Allis-Chalmers branch office at York, Pa. An electrical engineering graduate of the Drexel Institute of Technology.

H. B. Bryans (M '17, F '18) president of the Philadelphia (Pa.) Electric Company, has been elected a trustee of the 100-year-old Penn Mutual Life Insurance Company. Mr. Bryans, who has been identified with the utility industry during his entire business career, became vice-president in charge of operations of the Philadelphia Electric Company in 1929. He was made executive vice-president in 1938, and in June of this year was elected president. He has been a director of the company since April 1940. Mr. Bryan was graduated as a mechanical engineer from the University of Pennsylvania. He is a director and past president of the American Standards Association, president of the Electrical Association of Philadelphia, director of the Edison Electric Institute, and a past president of the Pennsylvania Electric Association.

L. S. Steiner (A '40) formerly electrical superintendent, steel and tube division, Timken Roller Bearing Company, Canton, Ohio, has been appointed superintendent of maintenance for the steel and tube division of that company.

OBITUARY

Francis Hiel Hollister (A '08, M '30, F '43) retired partner and chief electrical engineer, Sargent and Lundy, Engineers, Chicago, Ill., died on September 20, 1947, at Winter Park, Fla. Born on October 5, 1882, in Cambridge, N. Y., he attended Northwestern University's college of liberal arts for two and a half years, later transferring to the University of Michigan. Mr. Hollister received a bachelor of science degree in electrical engineering from the latter school in 1906, and then he accepted a position with the General Electric Company in Schenectady, N. Y. He was engaged in test work for that concern until 1908 when he was promoted to estimator. In 1910 he was advanced to the position of engineer in the lighting engineering department, and in 1912 he was made apparatus engineer in the General Electric Company's district engineer's office, Atlanta, Ga. Mr. Hollister left that concern's employ in 1916 to accept a position as an electrical engineer with the firm of Sargent and Lundy, and he remained in that capacity until 1930 when he was promoted to chief electrical engineer with that firm. He retired from that organization in 1946. Mr. Hollister has served on a number of AIEE committees: power generation, 1929–38, chairman 1935–36; technical program, 1935–36; and protective devices, 1944–45. He was also a member of the Western Society of Engineers.

Harold Kinyon Doyle (M '38, F '45) assistant to the president, Dallas (Tex.) Power and Light Company, died on September 27, 1947. Born in Pittsburgh, Pa., on June 13, 1899, he was graduated with a bachelor of science degree from the University of Pittsburgh in 1923. After graduation he joined the West Penn Power Company, Washington, Pa., as an electrician. He was promoted to the position of construction foreman in 1924, and was named distribution engineer of the company's office in Pittsburgh, Pa., in 1925. He left that organization in 1929 to accept an opening with the Electric Bond and Share Company, New York, N. Y., as distribution engineer. In 1931 Mr. Doyle transferred to the Dallas Power and Light Company in the capacity of distribution engineer, and he became the head of the construction engineering department of that concern in 1932. He was appointed chief engineer in 1935, operating superintendent in 1942, and assistant to the president, the position which he held at the time of his death, in 1947. Mr. Doyle had been a member of the board of directors of the Dallas Light and Power Company since 1940. He was active in the affairs of the North Texas Section of the AIEE, serving as treasurer of the Section for the year 1944–45, secretary in 1945–46, and as chairman for 1946–47. He was also a member of the National Society of Professional Engineers.

Francis Joseph White (A '02, M '15) electrical engineer, sales department, The Okonite Company, New York, N. Y., died on October 4, 1947. Born in Brooklyn, N. Y., on August 24, 1880, Mr. White later attended the College of the City of New York and the school of engineering at Columbia University where he received an electrical engineering degree in 1902. After graduation he served first as an instructor of electrical engineering at Columbia University, New York, N. Y., and then entered the employ of the New York (N. Y.) Edison Company (now the Consolidated Edison Company of New York (N. Y.) Inc.) in 1903. He left that organization in 1904 to join the Gould Storage Battery Company, Depew, N. Y., as a construction engineer, and subsequently the New York Central Railroad

System in 1906 as a storage battery engineer. He transferred to the Pennsylvania Tunnel and Terminal Railroad Company's offices in New York, N. Y., where he served in the capacity of assistant engineer in the electrical department. He joined The Okonite Company in 1910 as an electrical engineer, and specialized in railroad and utility problems involving electric wires and cables. Mr. White served on many technical committees of the American Standards Association, the American Transit Association, and the Association of American Railroads. He was a member of the New York Railroad Club, the National Society of Professional Engineers (Kings County Chapter), the Engineers Club, and of the Columbia University Club.

Cyrus Wellington Koiner (A '04, M '07, F '12) retired city manager, City of Pasadena, Calif., died on September 29, 1947. Born in Augusta County, Va., on May 17, 1870, he later received his technical education from the International Correspondence School, Scranton, Pa. In 1892 Mr. Koiner was employed by the Keeley Institute, Laurel, Md., working in the field of electrical engineering, and from 1893 to 1898 he was in charge of the Laurel (Md.) Electric Light, Heat, and Power Company, serving in the capacity of engineer and manager. In 1898 he joined the Oneida (N. Y.) Light and Power Company, in the same capacity, where he stayed until the company was merged with the Madison County Gas and Electric Company in 1901. Mr. Koiner then was made engineer of the four plants involved in that merger, and in 1904 became president and manager of the entire Madison County Gas and Electric Company. He resigned from that position in 1905 to affiliate himself with the National Light and Improvement Company, St. Louis, Mo., as an electrical engineer. In 1907 he went to California to serve as general superintendent and engineer of the Los Angeles Gas and Electric Company, but after six months he resigned to accept a position as general manager and electrical engineer for the City of Pasadena's municipal light and power plant, which he built and operated. In 1921 Mr. Koiner was the unanimous choice for the City of Pasadena's first city manager. During the next four years he distinguished himself in the field of city management and was elected president of the International City Managers' Association. From 1925 to 1933 he held the position of district manager with the Edison Company, and in 1933 he returned as Pasadena's chief executive. When the Federal Government undertook a $200,000,000 power development in 1935, Mr. Koiner was asked to serve as a consultant to the Department of Interior, and he is considered the father of Pasadena's municipal light plant. He retired as city manager a year and a half ago, after approximately 30 years of service. He was the first chairman of the Los Angeles (Calif.) Section of the AIEE, the dean of city managers in the United States, and the author of the city manager's code of ethics now in effect. Mr. Koiner was a member of the American Society of Mechanical Engineers, and of the American Gas Institute.

Edward Arthur Baldwin (A '07) retired vice-president, International General Electric Company, Inc., Paris, France, died on September 27, 1947, in Beau Montel, France. Born on May 7, 1874, at Hyde Park, Mass., Mr. Baldwin received his technical education at the Massachusetts Institute of Technology from which he was graduated with a bachelor of science degree in 1896. He then entered the employ of the General Electric Company, serving in the testing department of the Schenectady, N. Y., plant for two years. In 1898 he was transferred to the engineering department of the company, at first engaged in railway engineering and then serving as an electrical engineer with the foreign department of that concern. When the International General Electric Company was formed in 1918, Mr. Baldwin was named manager of the European division, and in 1927 he moved his headquarters from Schenectady to Paris. He was made a vice-president in 1938. With the outbreak of the recent war he returned to the United States, and he retired in 1940. Mr. Baldwin had been traveling in France for several months at the time of his death. He was active in international affairs, and had been decorated by the government of France as an officer of the Legion of Honor. He served as president of the American Chamber of Commerce in France for many years and was appointed observer for the United States Government at the International Labor Conference in Geneva in 1934.

Edward Hall Faile (M '31) consulting engineer, Westport, Conn., died at his winter home on Jupiter Island, Fla., on February 21, 1947, according to a report just received. Born in New York, N. Y., on January 14, 1884, Mr. Faile was a 1906 graduate of Cornell University, from which he received his mechanical engineering degree. In 1906 he was employed as an assistant to John S. Griggs, consulting engineer, New York, N. Y., and then in 1907 he was construction superintendent during the construction of the City Investing Building, New York, N. Y. He was also resident engineer in charge of construction of the Symington Malleable Iron Plant, Rochester, N. Y., in 1909; engineer with the L. K. Comstock and Company, New York, N. Y., electrical contractors, in 1911; chief engineer of the Adams Express Building Company in 1912–14; supervising engineer for the Oceanic Investing Company 1914–15; and in his own private business from 1915 to 1917. During the first World War, Mr. Faile was resident engineer of the Emergency Fleet Corporation during the construction work at Port Newark, N. J. He later was affiliated with several other firms, and then organized a private consulting business under the name of E. H. Faile and Company. Mr. Faile was a member of the American Society of Civil Engineers and an associate fellow of the Institute of the Aeronautical Sciences.

William Reginald Barrett (A '22) retired assistant division superintendent, Utah Power and Light Company, Salt Lake City, died on September 22, 1947. Born on August 8, 1881, at Southampton, England, he later received his technical training through a course given by the Electric Power and Lighting Company. From 1904 to 1907 Mr. Barrett was affiliated with a telephone company, transferring then to the Utah Light and Railway Company. He was engaged as a cable splicer and also in transformer and meter work both with the afore-mentioned companies and with the Utah Power and Light Company with which he next was associated. In 1920 he was promoted to general line foreman and later he was advanced to the position which he held at the time of his retirement in 1946.

Edward Young Rice (A '13) superintendent of the meter department, Hartford (Conn.) Electric Light Company, died on September 29, 1947. Born in Rensselaerville, N. Y., on September 14, 1888, he later attended Rensselaer Polytechnic Institute from which he received his electrical engineering degree in 1911. From 1911 to 1914 Mr. Rice was an assistant professor in electrical engineering and physics at Rensselaer Polytechnic Institute, Troy, N. Y., transferring at that time to the Hartford Electric Light Company as an electrical engineer in the standardizing laboratory. He was advanced successively to the positions of motor and power sales engineer, assistant purchasing agent, illuminating engineer, superintendent of lighting, and finally to superintendent of the meter department. Mr. Rice was a member of the National Electric Light Association.

Floyd Franklin McCammon (A '28, M '44) vice-president in charge of electrical operations, Public Service Company of Colorado, Denver, died on September 20, 1947. Born on December 10, 1889, at Colorado Springs, Colo., he received a bachelor of science degree in electrical engineering from Colorado College in 1916. From 1916 until the first World War, in which he served in the United States Navy as an ensign, Mr. McCammon was a junior engineer with the Public Service Company of Colorado. In 1919 he returned to the company as an engineer, and was advanced to the position of power salesman in 1920. He was promoted to assistant general superintendent in 1928 and advanced to general superintendent

in charge of electrical operations in 1940. Mr. McCammon was named vice-president in charge of electrical operations in 1943, and he was appointed a director of the Public Service Company in 1939. He was chairman of the professional courtesy committee of the AIEE for the year 1945–46; a director of the Denver, Colo., Chamber of Commerce; and a member of the city planning commission, Phi Gamma Delta fraternity, the University club, and of the Denver Club.

George Albert Chadwick (M '46) vice-president in charge of engineering, Vickers Incorporated, Detroit, Mich., died on October 1, 1947, in Frederick, Md. Born on March 15, 1881, in Brooklyn, N. Y., Mr. Chadwick was a graduate in electrical engineering of George Washington University, where he later took special courses in physics and mechanical and electrical engineering. From 1898 to 1900 he was associated with the Rogers Locomotive Works, Paterson, N. J., and then he joined the Schenectady (N. Y.) Locomotive Works where he was engaged in locomotive design. Mr. Chadwick was affiliated with the Richmond (Va.) Locomotive Works from 1901 to 1904, when he left to accept a position as leading ordnance draftsman at the United States Naval Gun Factory. In 1918 he was appointed head engineer in charge of all ordnance design at the Bureau of Ordnance, Navy Department, Washington, D. C., and he remained in that station until 1943, when he received the position which he held at the time of his death. Mr. Chadwick was also a professor of analytical mechanics and strength of materials at George Washington University, Washington, D. C., from 1928 to 1934. He was a member of the Society of Automotive Engineers, the Society of Naval Architects and Marine Engineers, and of the American Society of Naval Engineers.

Paul Joseph Turregano, Jr. (A '45) electrical engineer, The National Supply Company, Houston, Tex., died on September 29, 1947, as a result of injuries received in an automobile accident on September 25, 1947. Born on May 7, 1921, in Alexandria, La., Mr. Turregano was graduated from Southwestern Louisiana Institute in 1942 with a bachelor of science degree in electrical engineering. From 1942 to 1943 he was employed as a draftsman with the United States War Department, post engineers, at Camp Claiborne, La., and in 1943 he was appointed an instructor in electrical engineering at Southwestern Louisiana Institute, Lafayette. Mr. Turregano joined the National Supply Company in 1946.

Charles Adam Mixer (A '03) retired consulting engineer, Rumford Falls (Maine) Light and Water Company, died on October 24, 1947. He was born on June 9, 1859, at Hamilton, Ohio. In 1883 Mr. Mixer was an assistant to the city engineer of Hamilton, engaged in municipal and hydraulic works, and from 1883 to 1886 he was affiliated with various railroad companies as an assistant engineer on location and construction. In 1886–88 Mr. Mixer was employed as principle assistant engineer in the design and construction of cable road in Cincinnati, Ohio, and in Denver, Colo., and from 1889 to 1890 he was engaged in the same capacity during the construction of the Providence Cable Trainway. In 1890–91 Mr. Mixer served as assistant to the city engineer and the commissioner of public works, Providence, R. I. He became affiliated with the Rumford Falls Light and Water Company in 1892 as a resident engineer, and was advanced to the position of consulting engineer in 1902. Mr. Mixer was a member of the American Society of Civil Engineers, and he was the originator of a method of estimating water content of snow cover, useful in long range forecasting of water storage probabilities and flood hazards.

MEMBERSHIP • •

Recommended for Transfer

The board of examiners, at its meeting of October 16, 1947, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Amstus, J. O., vice pres. chg. of engg. & mfg., Behr Manning Corp., Troy, N. Y.

Bancker, E. H., application engr., federal & marine engg. div., General Elec. Co., Schenectady, N. Y.

Baugh, C. E., elect. dist. engr., Pacific Gas & Elec. Co., San Francisco, Calif.

Chambers, D. E., executive engr., research lab., General Elec. Co., Schenectady, N. Y.

Clark, H. W., asst. engr. of distribution, Potomac Elec. Pr. Co., Washington, D. C.

Dunlap, G. W., asst. div. engr., General Elec. Co., Schenectady, N. Y.

Fowler, C. V., toll plant extension engr., The Pacific Tel. & Tel Co., San Francisco, Calif.

Herskind, C. C., elec. engr., General Elec. Co., Schenectady, N. Y.

Hill, L. W., pres., Carolina Tel & Tel Co.; Home Tel & Tel Co., Tarboro, N. C.

Hobson, J. E., director, Armour Research Foundation, Chicago, Ill.

Hunter, E. M., product application engr., General Elec. Co., Schenectady, N. Y.

Kaufmann, R. H., application engr., General Elec. Co., Schenectady, N. Y.

Peterson, J. B., elect. engr., P-4, Naval Research Lab., Washington, D. C.

Roberts, F. M., asst. mgr., industrial engg. div., General Elec. Co., Schenectady, N. Y.

Rumsey, A. L., chief engr., N. Y. Tel. Co., Albany, N. Y.

15 to grade of Fellow

To Grade of Member

Arnn, E. L., engr., The McPherson Co., Greenville, S. C.

Berger, R. C., application engr., General Elec. Co., Cleveland, Ohio.

Biesele, R. L., Jr., prof. & chmn, elec. engg. dept., Southern Methodist Univ., Dallas, Tex.

Bloodworth, T. H., control engr., Allis-Chalmers Mfg. Co., West Allis, Wis.

Bunnell, R. F., supt. electrical construction dept., Warner Bros. Studio, Burbank, Calif.

Dent, W. E., Jr., elec. engr., The Springs Cotton Mills, Lancaster, S. C.

Donaldson, W. L., asst. prof. elec. engg., Lehigh Univ., Bethlehem, Pa.

Foster, E. B., consulting elec. engr., Sheffield, Ala.

Gaynor, A. M., assoc. of J. S. Hamel, C.E., New York, N. Y.

Glueckstein, H. J., product engr. Centralab Div. of Globe Union, Inc., Milwaukee, Wis.

Jenner, R. R., supv. elec. engg., Beech Aircraft Corp., Wichita, Kans.

Lazzari, A., senior elec. engr., Central Arizona Lt. & Pr. Co., Phoenix, Ariz.

Lebens, J. C., Jr., elec. engr., Bussmann Mfgr. Co., St. Louis, Mo.

Litchfield, R. B., equipment engr., New Jersey Bell Tel. Co., Newark, N. J.

Madill, J. T., elec. engr., Aluminum Co. of Canada, Ltd., Shipshaw, Cyre., Can.

Moorthy, C. V. D., principal-in-charge; head elec. engg. dept., Osmania Technical College, Hyderabad, Deccan, India.

Norton, K. A., physicist, central radio propagation lab., National Bureau of Standards, Washington, D. C.

Peterman, H. A., chief elec. engr., Hyperion Sewage Treatment Plant, R. E. Phillips, C. E., Los Angeles, Calif.

Phillips, R. E., relay engr., Kansas Gas & Elec. Co., Wichita, Kans.

Reed, R. H., Columbus, Nebr.

Redmond, J. J., applied physics lab., Johns Hopkins Univ., Silver Spring, Md.

Rempt, H. F., elec. staff engr., Lockheed Aircraft Corp., Burbank, Calif.

Ridpath, L. W., professional engr., electrical tel. div., Stromberg-Carlson Co., Rochester, N. Y.

Ryder, G. C., asst. engr., Public Service Elec. & Gas Co., Camden, N. J.

Schulke, A. A., engineer-in-charge, cyclotron lab., Washington Univ., St. Louis, Mo.

Schwartz, L. S., radio engr., Naval Research Lab., Washington, D. C.

Schwarz-Kast, E. L., Armour Research Foundation, Chicago, Ill.

Stack, J. E., elec. engr., Franque A. Dickins, engr., Brooklyn, N. Y.

Thomas, H. A., research physicist, National Bureau of Standards, Washington, D. C.

Zimmer, A. A., maintenance engr., The Davison Chemical Corp., Baltimore, Md.

30 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before December 21, 1947, or February 21, 1948, if the applicant resides outside of the United States or Canada.

To Grade of Fellow

Ingles, H. C., Maj. Gen., RCA-Communications, New York, N. Y.

1 to grade of Fellow

To Grade of Member

Allan, W. A., Universal Atlas Cement Co., New York, N. Y.

Anderson, H. J., General Motors Inst., Flint, Mich.

Appel, H. J., Socony-Vacuum Oil Co., New York, N. Y.

Armstrong, R. E., Consumers Power Co., Flint, Mich.

Axman, E., Pennsylvania State College, State College, Pa.

Bennett, A. F., Bell Tel. Labs., Inc., Murray Hill, N. J.

Bonway, J., General Elec. Co., Dayton, Ohio.

Burgess, T. J., Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada.

Cobb, P. G., Weston Elec. Instrument Corp., Newark, N. J.

Collins, H. L. J., Commonwealth Edison Co., Chicago, Ill.

Dalton, J. P., Contractors' State License Board, San Francisco, Calif.

Egeland, R., Illinois Bell Tel. Co., Rockford, Ill.

Godwin, H. B., Consolidated Vultee Aircraft Corp., Daingerfield, Tex.

Grundfest, H., Columbia Univ., New York, N. Y.

Hambley, J. M., Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada.

Hammell, K. M., Eureka Williams Corp., Bloomington, Ill.

Henderson, T. W., Greenwood County Rural Elec. System, Greenwood, S. C.

Hutchcroft, G. E., Dept. of Water & Power, Los Angeles, Calif.

Jones, G. P., The Chesapeake & Potomac Tel. Co. of West Virginia, Charleston, W. Va.

Lagrone, P. T., Westinghouse Elec. Corp., East Pittsburgh, Pa.

Lanier, W. J., Southern Bell Tel. & Tel. Co., Nashville, Tenn.
McBean, J. M., Jackson & Moreland, Boston, Mass.
Pierce, H. D., Universal Wire & Cable Co., Chicago, Ill.
Raymond, A. H., Ind. Business Machines Corp., Poughkeepsie, N. Y.
Rider, W. J., Walter J. Rider Co., Inc., Binghamton, N. Y.
Robison, M., The Toledo Edison Co., Toledo, Ohio.
Rogoff, J., Burndy Engg. Co., Inc., New York, N. Y.
Silbermann, H., S. A. Philips, Pty. Ltd., Johannesburg, South Africa.
Sullivan, E. M., Springfield Elec. Co., Springfield, Mass.
Thomas, S. O., The Hobart Mfg. Co., Troy, N. Y.
Tremaine, A. E., Westcott & Mapes, Inc., New Haven, Conn.
Watson, A. J., Jr., Mississippi Power Co., Gulfport, Miss.
Wong, G. K., Ebasco Services, Inc., New York, N. Y.

33 to grade of Member

To Grade of Associate

United States, Canada, Mexico, and Puerto Rico

1. NORTH EASTERN

Allia, D. J., New England Power Service Co., Worcester, Mass.
Bagg, A. G., Eastman Kodak Co., Rochester, N. Y.
Beckwith, R. F., Eastman Kodak Co., Kodak Park, Rochester, N. Y.
Carroll, D. D., Eastman Kodak Co., Kodak Park, Rochester, N. Y.
Cleaveland, A. N., N. Y. State Elec. & Gas Corp., Ithaca, N. Y.
Conrow, C. L., Intl. Business Machines Corp., Endicott, N. Y.
Cooke, C. L., Eastman Kodak Co., Kodak Park, Rochester, N. Y.
Desnoyers, H. B., N. Y. State Inst. of Applied Arts & Sciences, White Plains, N. Y.
Dolan, J. T., Westcott & Mapes, Inc., New Haven, Conn.
Flowers, T. A., Intl. Business Machines, Endicott, N. Y.
Gaffney, J. F., Intl. Business Machines, Endicott, N. Y.
Geadminski, B. F., Boston Naval Shipyard, Charleston, Mass.
Jarvis, L. N., Sr., Standard Elect. Time Co., Springfield, Mass.
Keller, I. W., N. Y. State Elec. & Gas Corp., Geneva, N. Y.
Kniffen, E. G., General Elec. Co., Binghamton, N. Y.
Laird, D. E., Chance Vought Aircraft, Stratford, Conn.
Ormiston, R. G., N. Y. State Elec. & Gas Corp., Ithaca, N. Y.
Pfuntner, R. A., General Elec. Co., Lynn, Mass.
Purdy, D., N. Y. State Elec. & Gas Corp., Binghamton, N. Y.
Riggs, M. L., General Elec. Co., Pittsfield, Mass.
Swanson, S. A., N. Y. State Elec. & Gas Corp., Ithaca, N. Y.
Thompson, E. L. (re-election) N. Y. State Elec. & Gas Corp., Ithaca, N. Y.
Thomson, C. M., Jr., Norwich Univ., Northfield, Vt.
Walrath, R. V., Rochester Tel. Corp., Rochester, N. Y.
Washington, J. C., Line Material Co., Albany, N. Y.
Wheeler, L. T., Intl. Business Machines Corp., Endicott, N. Y.
Wigtil, W. O., Eastman Kodak Co., Rochester, N. Y.

2. MIDDLE EASTERN

Abel, G. A., General Elec. Co., Philadelphia, Pa.
Ayres, G. H., Gould Ayres & Associates, Columbus, Ohio.
Davis, J. L., Sperry Gyroscope Co., Inc., Baltimore, Md.
Day, S. D., The Ohio Power Co., Canton, Ohio.
Dustman, W. S., Taylor-Winfield Corp., Warren, Ohio.
Geotz, T. J., The Atlantic Refining Co., Philadelphia, Pa.
Godwin, W. E., Philadelphia Elec. Co., Philadelphia, Pa.
James, E. A., Jr., Westinghouse Elec. Corp., Sharon, Pa.
Kirkbride, C. R., Pennsylvania Transformer Co., Canonsburg, Pa.
Kreider, C. A., Westinghouse Elec. Corp., Sharon, Pa.
Leland, R. W., General Motors Corp., Delco Products Div., Dayton, Ohio.
Raming, R. B., Cincinnati Gas & Elec. Co., Cincinnati, Ohio.
Robinson, R. B., Wright Field, Dayton, Ohio.
Schiff, H. G., Jr., General Elec. Co., Philadelphia, Pa.
Sholtis, J. J., Cleveland Elec. Illuminating Co., Cleveland, Ohio.
Taylor, E. J., Ford, Bacon & Davis, Charleston, W. Va.
Webking, H. E., General Motors Corp., Delco Products Div., Dayton, Ohio.
Whelan, W. T., Naval Ordnance Lab., Washington, D. C.
Wilkinson, J. J., English Elec. Co., Ltd., c/o Westinghouse Elec. Corp., East Pittsburgh, Pa.
Wilson, T. C., 2782 Collis Ave., Huntington, W. Va.

3. NEW YORK CITY

Blodgett, M. C., Intl. Business Machines Corp., Poughkeepsie, N. Y.
Brenner, E., City College School of Tech., New York, N. Y.
Carson, A., Sanderson & Porter, New York, N. Y.
Garcia, V. S., College of Agri. & Mech. Arts, Mayaguez, Puerto Rico.
Gill, J. J., N. Y. Tel. Co., New York, N. Y.
Laikevich, A., Product Development Co., Inc., Arlington, N. J.
Lipschultz, L. L., M. W. Kellogg Co., Jersey City, N. J.
Marino, A. J., Westchester Lighting Co., Mt. Vernon, N. Y.
Matthysse, I. F. (re-election), Burndy Engg. Co., New York, N. Y.
Nolan, D. C., III, Westchester Lighting Co., Mt. Vernon, N. Y.
Rudolph, H., Ebasco Services, Inc., New York, N. Y.
Tishler, H. G., Lexington Elec. Products Co., New York, N. Y.
Vonderau, J. F., Sanderson & Porter, New York, N. Y.
Zengel, J. F. P., Manhattan College, New York, N. Y.
Zisserman, M., Norden Laboratories Corp., White Plains, N. Y.

4. SOUTHERN

Barnett, L. H., Jr., Carbide & Carbon Chem. Corp., Oak Ridge, Tenn.
Bushnell, R. O., Florida Power & Light Co., Miami, Fla.
Carlson, J. R., General Elec. Co., Knoxville, Tenn.
Clifton, F. K., Williamson Sales Co., Shreveport, La.
DeLany, D. C., Jr., TVA, Chattanooga, Tenn.
Ellerbe, J. E., South Carolina Power Co., Fairfax, S. C.
Enger, W. H., Alabama Power Co., Birmingham, Ala.
French, J. W., Appalachian Elec. Power Co., Roanoke, Va.
Phipps, J. K., Carbide & Carbon Chem. Corp., Oak Ridge, Tenn.
Smith, J. W., TVA, Chattanooga, Tenn.
Smith, M., Engineer Research & Development Labs., Ft. Belvoir, Va.
Wheeler, A. W., Graybar Elec. Co., Shreveport, La.
Williams, W. L., Jr., Dan River Mills, Inc., Danville, Va.

5. GREAT LAKES

Behnke, W. B., Jr., Public Service Co. of No. Illinois, Glencoe, Ill.
Copp, A. D., Wisconsin Elec. Power Co., Milwaukee, Wis.
Decker, W. J., Commonwealth Edison Co., Chicago, Ill.
Deming, S. E., Clark Equipment Co., Buchanan, Mich.
Grover, A., Fischbach, Moore & Morrissey, Decatur, Ill.
Hafstrom, J. R., Univ. of Wisconsin, Madison, Wis.
Hawley, A. C., Illinois Central Tel. Co., Chillicothe, Ill.
Helm, M. S., Univ. of Illinois, Urbana, Ill.
Homan, R. A., Wisconsin Elec. Power Co., Milwaukee, Wis.
Johnson, L. R., Western Elec. Co., Inc., Chicago, Ill.
Johnson, S. E., Illinois Northern Utilities Co., Dixon, Ill.
Kilty, D. E., Caterpillar Tractor Co., Peoria, Ill.
Kori, A. F., Allis-Chalmers Mfg. Co., West Allis, Wis.
Lamond, R., Jr., Western Elec. Co., Chicago, Ill.
May, R. L., Western Elec. Co., Inc., Chicago, Ill.
McFarland, J. W., General Elec. Co., Milwaukee, Wis.
McIntyre, B. F., Northern Indiana Public Service Co., Hammond, Ind.
Nowak, M. J., Commonwealth Edison Co., Chicago, Ill.
Plaia, C., Caterpillar Tractor Co., Peoria, Ill.
Sapphire, A., Public Utilities Engg. & Service Corp., Chicago, Ill.
Seibold, D. W., Western Elec. Co., Chicago, Ill.
Shrake, C. D., Caterpillar Tractor Co., Peoria, Ill.
Stevens, H. R., Illinois Bell Tel. Co., Chicago, Ill.
Trenary, H. I. (re-election), General Elec. X-Ray Corp., Milwaukee, Wis.
Watson, R. E., Northern Indiana Public Service Co., Hammond, Ind.
Wendt, R. E., Jr., Univ. of Illinois, Champaign, Ill.
Wood, G. W., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

6. NORTH CENTRAL

Priest, F. F., U. S. Bureau of Reclamation, Denver, Colo.

7. SOUTH WEST

Baird, K., South Western Public Service Co., Amarilla, Tex.
Blakestad, R. B., Arkansas State College, State College, Ark.
Case, J. F., H. N. Roberts & Associates, Lubbock, Tex.
Choate, W. M., Consolidated Steel Corp. of Texas, Orange, Tex.
Davis, L. L., Southwestern Public Service, Amarillo, Tex.
Litton, F., Jr., H. N. Roberts & Associates, Lubbock, Tex.
Lumsden, E. N., Cities Service Gas Co., Oklahoma City, Okla.
McGinnis, J. J., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
McMillin, J. M., Jr., Dallas Power & Light Co., Dallas, Tex.
Moore, J. A., Westinghouse Elec. Corp., Oklahoma City, Okla.
Mullings, M. E., Abilene Christian College, Abilene, Tex.
Rubio y L., M., Av. Juarez 30-108, Mexico, D. F., Mexico.
Turner, S. S., Jr., Gulf States Utilities Co., Beaumont, Tex.

8. PACIFIC

Arnold, J. S., Trumbull Elec. Mfg. Co., North Hollywood, Calif.
Coe, G. T., Tucson Gas, Elec. Light & Power Co. Tucson, Ariz.
Davidson, J. F., Consolidated Engg. Corp., Pasadena, Calif.
Davis, A. W., Earl S. Condon Co., Los Angeles, Calif.
Glover, E. C., State Polytechnic College, San Luis Obispo, Calif.
Hudlow, L. J., Bureau of Reclamation, Boulder City, Nev.
Klopfenstein, A., Southern Calif. Edison Co., Los Angeles, Calif.
Lowe, A. F., The Pacific Tel. & Tel. Co., San Jose, Calif.
McKinney, R. C., North American Aviation, Inc., Los Angeles, Calif.
Price, E. P., U. S. Bureau of Reclamation, Redding, Calif.
Rubly, E. J., Dept. of Water & Power, Los Angeles, Calif.
Short, C. M. (re-election), Dept. of Water & Power, Los Angeles, Calif.
Smith, K. S., Dept. of Water & Power, Los Angeles, Calif.
Stephenson, J. N., Dept. of Water & Power, Los Angeles, Calif.
Stine, C. E., Southern California Edison Co., Los Angeles, Calif.
Tamkin, S. J., Univ. of Southern Calif., Los Angeles, Calif.
Thomson, G. A., U. S. Bureau of Reclamation, Redding, Calif.
Tyler, M. G., Douglas Aircraft Co., Inc., El Segundo, Calif.
Van Kirk, C. A. (re-election), U. S. Naval Shipyard, Mare Island, Vallejo, Calif.
White, C. J., General Elec. Co., Los Angeles, Calif.
Wyatt, W. W., U. S. Navy Electronics Lab., San Diego, Calif.
Young, J. T., Elec. Supplies Distributing Co., San Diego, Calif.

9. NORTH WEST

Kanzler, H. W., Fred W. Carlson, Seattle, Wash.
Parker, M. C. (re-election), Robt. Welty, The Dalles, Oreg.
Peterson, C. H., Univ. of Idaho, Moscow, Idaho.
Rinker, L. E., Leupold & Stevens Instruments, Portland, Oreg.
Schoolcraft, E. H., Northwest Nut Growers, Dundee, Oreg.
Schwartz, J. F., General Elec. Co., Portland, Oreg.
Towle, F. L., Jr., City Engineer's Office, Eugene, Oreg.
Wheeler, H. F., Portland General Elec. Co., Portland, Oreg.

10. CANADA

Brazier, D. B., Automatic Electric (Canada) Ltd., Toronto, Ontario, Canada.
Cullingworth, A. J., Amalgamated Electric Corp., Toronto, Ontario, Canada.
Fairhurst, E., Turnbull Elevator Co. Ltd., Hamilton, Ontario, Canada.
Fraser, G. M., D. M. Fraser, Ltd., Toronto, Ontario, Canada.
Hole, J. H., Canadian General Elec. Co., Toronto, Ontario, Canada.
Jessup, D. G., Northern Elec. Co., Vancouver, British Columbia, Canada.
Martin, D. F., Packard Elec. Co., Ltd., Toronto, Ontario, Canada.

Elsewhere

Bandeira de Lima, A., Tramway Lt. & Pr. Co., Ltd., Rio de Janeiro, Brazil, South America.
Barr-Wells, D. R., English Elec. Co. Ltd., Stafford, England.
Brendan, P. B., University College, Dublin, Ireland.
Bubenko, J. A., The Royal Inst. of Tech., Stockholm, Sweden.
Herman, I., General Elec. Co., S. A., Rio de Janeiro, Brazil, South America.
Stephen, D. D., British Thomson-Houston Co., Ltd., Rugby, England.

Total to grade of Associate

United States, Canada, Mexico, and Puerto Rico, 153

Elsewhere 6

OF CURRENT INTEREST

Third National Electronics Conference Features 20 Technical Sessions

More than 2,400 people attended the third National Electronics Conference which was held in Chicago, Ill., November 3–5, 1947. About 1,900 of this number were paid registrations, and the balance was made up to students and exhibitors.

A wide range of subjects covering the entire electronics field were discussed at the 20 technical sessions which included the presentation of some 78 technical papers.

The National Electronics Conference, Inc., is a nonprofit organization, which serves as a national forum for the presentation of authoritative technical papers on electronic research, development, and application. It is sponsored jointly by the AIEE, the Illinois Institute of Technology, Northwestern University, University of Illinois, and the Institute of Radio Engineers. The Chicago Technical Societies Council is a co-operating society.

W. L. Everitt (F '36) head of the electrical engineering department of the University of Illinois, presided at the opening general meeting which featured three speakers.

OBJECTIVES

"National Electronics Conference Objectives" was the subject of a talk by Doctor G. H. Fett (M '38) associate professor of electrical engineering, University of Illinois. This talk served as an introduction to the conference. Doctor Fett cited the objective of the meeting as being: to outline the progress of the science of electronics, to provide a yearly panel of discussion, and to record these discussions in the "Proceedings of the National Electronics Conference."

Doctor Fett is vice-president of the National Electronics Conference.

The next speaker was Doctor G. D. Stoddard, president of the University of Illinois, who spoke on the subject, "Science as a Guide to Education." He pointed out that too many people are advocating stopping further research because apparently the results of research and science have produced nothing but more and more terrible weapons and methods of warfare. He cited the case of an atomic bomb research worker who, about six months ago, published an article in the *Atlantic Monthly* giving reasons why he has severed all connections with this work. Doctor Stoddard took issue with these ideas in general, pointing out that running away from a problem, either mentally or physically, never could result in a solution. His idea was additional research especially in the field of humanity. He referred to a new series of studies called "communication" which were being initiated at the University of Illinois. This course aims to present for further study all the various ways in which men exchange or convey ideas.

ELECTRONICS OF AGE

The final speaker at the opening general session was Doctor L. V. Berkner (M '36) of the Joint Research and Development Board, whose topic was "Electronics Comes of Age." His thesis was that as electronics comes of age, the future is bright and its potentialities unlimited if it meets the responsibilities for constant self-renewal, and for creative vision, enterprise, and initiative. He pointed out that continued growth and welfare of the electronics industry depend importantly on renewal and expansion of the industry through constant generation and advance of ideas. Support of research is an economic matter required for the welfare of the industry, and it is also a cultural matter deserving of support of the whole community. This was cited as one of the challenges which the electronics profession and industry faces as electronics comes of age.

Another challenge was the one to produce great systems which will meet the needs of vital importance to the economic welfare and security of the United States. Doctor Berkner cited as examples of such needs air navigation and freight dispatching. Regarding the former point he mentioned there have been tremendous strides toward the solution of individual elements of the problems—the instrument landing system of the Civil Aeronautics Authority, ground control approach, multichannel very-high-frequency communication, and others of equal or greater importance. However, it is questionable whether a really satisfactory system is in sight. This was cited as a really big systems problem which must be conceived and operated on a national scale, and one which extends beyond the resources of a single corporation. He advocated a committee procedure to solve this type of problem. The committee can bring together the diverse points of view representing different aspects of the problem to insure that each significant facet is considered, it can recognize the feasibility of solutions along generalized lines, it can determine the probable limitations on the several solutions, and it can advocate the means whereby the problem can be formulated in detail and the solution processed. Doctor Berkner cited the telephone industry, the electric power industry, and the engineering and construction of the Hoover Dam as examples that demonstrated that industry can do a big new system job if properly organized, and that it must integrate when the size of the job to be done exceeds the resources of its individual elements. He mentioned the problem of freight dispatching as one of a big systems type of problem which lends itself to solution by the method previously outlined. The two problems cited were selected for discussion because their solution probably will be one in which electronics can undertake a vital role.

Doctor Berkner concluded with the thought that the creation of the really large and important things of the future, those things which require extensive systems thinking and development, are dependent on adequate initiative and support by sufficiently integrated research and industrial groups. He pointed out that in a country where private enterprise is dominant, it should take the lead, and that the measure of free enterprise is its ability to exercise its leadership.

RESEARCH FOR GOVERNMENT

A luncheon meeting presided over by A. B. Bronwell (M '44) president of the National Electronics Conference, was held in the Marine dining room of the Edgewater Beach Hotel. During this gathering, Walter Evans, vice-president, Westinghouse Electric Corporation, spoke on "Research and Development for Government Projects." He proposed sweeping changes in national preparedness thinking under which science and industry would be admitted to full membership, along with the military, in top level planning councils. He suggested that American security be entrusted to a "combat team" of four departments:

1. A military high command to map plans and list requirements in the light of existing tools of defense.
2. A nation-wide research organization to maintain a never-ending vigil in the laboratories seeking out new devices and techniques.
3. An industrial militia to convert the scientists' models to production line equipment, and to establish manufacturing procedure for passing along to subcontractors in times of emergencies.
4. An Army, Navy, and Air Force adequate to test equipment in the field and to train efficient operating and maintenance personnel.

Mr. Evans charged the United States with a persistent record of hindsightedness in applying its tremendous civilian research "know-how" to military matters. He pointed out that it was necessary to modernize our thinking about military procurement to include scientific brains, along with bullets and other measurables, if we are to live in peace in the atomic age.

Closing the first day's activities a banquet

was held in the Marine dining room. A floor show was presented, and the guests spent the remainder of the evening dancing.

HULL SPEAKS

AIEE President B. D. Hull spoke at the luncheon meeting on the second day of the conference, at which J. E. Hobson (M '41) Armour Research Foundation of the Illinois Institute of Technology, and chairman of the AIEE Chicago Section presided. Mr. Hull's topic was "An American Engineering Association." He indicated the need for an over-all organization to take care of the engineer's professional needs, and he visualized an organization which would encompass all engineering organizations, and yet maintain their individual technical autonomy. He pointed out that the technical activities of the individual societies would be maintained just as they are at present. However, such problems as professional standards, professional developments, definition and classification of an engineer, and so on, would be handled by the joint society. He said that the need for this type of organization was very real as was attested to by personal observation, discussions with members of other societies, and by the recent AIEE poll in which four plans were proposed and members were invited to make their selections. The plan which provided for an over-all engineering organization led the rest in popularity, obtaining more than 70 per cent of the votes sent in. Mr. Hull proposed that now is the time for the various societies to get together to discuss this problem in detail, and to outline possible procedures by which such an over-all American engineering organization could be organized.

TECHNICAL SESSIONS

During the 3-day conference some 20 technical sessions were held, at which 78 technical papers were presented. These are reviewed in detail in another section of this issue of *ELECTRICAL ENGINEERING* (*pp 1220–9*).

One of the technical sessions was a joint session of the AIEE and the National Electronics Conference. AIEE members attending the Midwest general meeting at the Congress Hotel in Chicago were invited to the National Electronics Conference at the Edgewater Beach Hotel where the joint session was held.

Atomic Physics Division Formed at National Bureau of Standards

The National Bureau of Standards has formed a Division of Atomic Physics in which the main bureau activities relating to atomic and molecular physics have been grouped together. The new division includes most of the basic lines of activity which made it possible for the Bureau of Standards to co-ordinate and direct, under its Presidential directive, the activities of the atomic bomb project from its inception in the fall of 1939 until 1942 when it developed into a large scale industrial undertaking.

FUNCTIONS

The functions of the new division are the promotion of fundamental fact-finding research and the precise determination of important fundamental standards in the field of atomic physics. This research will be applied to the establishment of primary and secondary standards of reference as, for example, calibrated sources of radiation, or meters for dosage, and the calibration of instruments used in atomic physics studies. It is also responsible for the development of protective and safety codes for the reduction of industrial hazards arising from new applications of physics and for the study of materials and equipment for the protection of the interests of the Government as a large consumer. Six sections make up the new division; spectroscopy, electronics, mass spectrometry, radioactivity, X rays, and atomic physics.

At the present time, the spectroscopy section is extending the analysis of atomic spectra—work pioneered at the bureau 25 years ago. One phase of this work is the study of the spectra of the new man-made elements as an addition to the already considerable work in progress on the completion of the knowledge of the structure of the natural elements. The section's infrared laboratory is extending the field of infrared spectroscopy, increasing the knowledge of molecular structure, and applying results to the structure of synthetic rubbers and the serviceability of textiles. The radiometry laboratory also is improving methods of measurement in the ultraviolet spectrum. The interferometry laboratory is applying optical interference methods to arrive at the most precise means known for the measurement of length and of flatness.

The electronics section is divided into two units. One is concerned with the basic physics of the emission of electrons and atomic ions from various materials under the influence of light, heat, or the impact of other electrons or ions. The other unit is concerned with the physics of electron and ion ballistics which are applied in the improvement of electron microscopes and the study of biological or metallurgical materials with the aid of electrons emitted by radioactive tracer elements.

The mass spectrometry section is applying this important research tool to chemical analysis, the control of production of synthetic rubbers, and the structure of organic plastics. The section also is engaged in the measurement of isotope ratios of tracers used by other laboratories.

The radioactivity section is the national standardizing laboratory for the measurement of radioactive materials and radioactive radiations. It has measured all commercially sold radium preparations from the time radium first became available in the United States in 1913 to the present time. Extremely sensitive methods have been developed for measuring radioactive contaminations in the air for the protection of industrial workers. This is an activity which is expanding because of the rapidly growing use of artificial radioactive materials now being supplied for research by the Atomic Energy Commission. Precise standards for the measurement of neutron radiation now are being developed.

X-RAY SECTION

The X-ray section is engaged in a program of measurement standardization and protection studies that are of particular importance to all research institutions using high-voltage X-ray equipment. Dosage control requires construction and maintenance of accurate primary standards of radiation dosage, a function of the Bureau of Standards. Recent development of high-voltage generators in the multimillion-volt range require extension of these fundamental studies into the new high energy regions. Last year the Congress gave substantial assistance to this program by providing for the purchase and installation of a 50 million-volt betatron and necessary auxiliary equipment. The betatron will be used not only for the development of protection standards in this voltage range, but also will be used in basic atomic physics research.

The main project of the atomic physics section is the precise determination of the atomic masses in order to give basic information about nuclear structure and to indicate available atomic energy. Work already has begun, in co-operation with the Office of Naval Research, to construct a large new instrument of novel design in order to accomplish this research.

Doctor E. U. Condon (M '44) the bureau's director, has assumed charge of the new division; Doctor Robert D. Huntoon has been named assistant chief. Doctor Huntoon was formerly chief of the electronics section in the ordnance development division and will continue as chief of this section which has been transferred into the new division. He received his doctorate in physics from the State University of Iowa in 1938. He became a member of the staff of the Bureau of Standards in 1941 and until 1944 worked on radio proximity fuse development. In 1944 his services were loaned to the War Department where he served as expert consultant on proximity fuses and related problems in the office of the Secretary of War.

Books for Finland. The library of the technical institute at Teknillinen Korkeakoulu, Finland, was bombed and totally destroyed during the war. Doctor Martti Levon, director of the institute, has issued a call, welcoming gifts of technical and

scientific books and periodicals from the United States to take the place of those destroyed during the war. Such a gift should be marked for the Institute of Technology, Helsinki, and sent to the Legation of Finland, 2144 Wyoming Avenue, N. E., Washington, D. C. Doctor K. T. Jutila, the Finnish minister, will arrange for shipment to Finland.

Tau Beta Pi Grants Three New Chapters

At its 42d convention held in New York, N. Y., October 9–11, 1947, Tau Beta Pi (national engineering honorary society) granted chapters to engineering student groups at Bucknell University, Lewisburg, Pa., Duke University, Durham, N. C., and University of Rochester, Rochester, N. Y., bringing the number of undergraduate chapters to 79.

Undergraduate student delegates from 76 engineering schools in the United States attended the convention which was arranged by the eight undergraduate chapters of Tau Beta Pi located in the metropolitan area and members of the association's New York alumnus chapter.

Engineers and Scientists Needed for Reclamation Projects

Several hundred engineers and scientists are needed at once in western field offices and on projects, to bring design and construction forces to strength needed to fulfill the construction program now under way.

Principal need is in the Missouri River basin states, where the Bureau of Reclamation has Congressional mandates to start construction of ten new dams this fiscal year. In addition, recent decentralization of various engineering services formerly performed at Denver, Colo., in order to meet Congressional directives, has brought a need for qualified personnel willing to man the 25 field design offices which are being established.

Openings for civil, mechanical, and electrical design and construction engineers, and soil and irrigation scientists, range from the P-4 Civil Service classification, with a starting salary of $4,902 per year, to P-1 with a starting salary of $2,644 per year. There are many openings for surveymen, engineering aides, agricultural aides, draftsmen, and related occupations, with salaries ranging from $1,690 to $3,397 a year.

All positions are in the 17 western states, Mr. Straus said, and inquiries should be addressed either to the Regional Director, Bureau of Reclamation, Billings, Mont., or the Regional Director, Bureau of Reclamation, Denver, Colo. Application forms, Federal Employment Form 57, may be obtained at any first or second class post office, or from the bureau's regional offices.

New employees for the most part will be working directly with the program known as the Missouri Basin Project, and appointments will be on a temporary basis except where persons are authorized to transfer or reinstatement based on present or previous federal service. However, persons holding temporary appointments, in general, will have opportunity to compete for career appointments at a later date. Qualified veterans will be given preference. Examinations will be announced periodically by the Civil Service Commission.

A few appointments will be available in the far West and Southwest, and inquiry for positions there may be made to the Regional Director, Bureau of Reclamation, Amarillo, Tex.; Boulder City, Nev.; or Sacramento, Calif.

The Missouri Basin Project, where the bulk of the openings are, will provide employment largely in Billings, Mont.; Bismarck, N. Dak.; Pierre, S. Dak.; Great Falls and Miles City, Mont.; Heart Mountain and Casper, Wyo.; Denver, Grand Junction, and Estes Park, Colo.; and Indianola, Nebr.

General Sims to Direct Fairchild's Atomic Project

Brigadier General Turner A. Sims, recently executive officer to the Assistant Secretary of War for Air, has been named general manager of Fairchild's NEPA (nuclear energy for the propulsion of aircraft) atomic energy project at Oak Ridge, Tenn. Frederick B. Kauffman, Captain United States Navy (retired), former director of the naval air experimental station in Philadelphia, Pa., will continue as assistant general manager of the project, a position which he assumed in May of this year.

NEPA is a project for the development of means whereby nuclear energy can be utilized to propel aircraft. It is being conducted by the Fairchild Corporation on behalf of the Army and Navy under an administrative contract with the United States Air Force. Leading aircraft power plant manufacturers, as well as the National Advisory Committee for Aeronautics, are participating in this industry-wide development project.

Electronic Engine Analyzer Developed for Aircraft

An electronic aircraft engine analyzer that can be used to locate and identify engine troubles during flight as well as on the ground has been announced by the Sperry Gyroscope Company. The device, which is known as the Sperry Engine Analyzer, is expected to eliminate lengthy trial-and-error engine trouble-shooting methods.

Essentially the system consists of a means of converting various operational cycles or physical phenomena occurring during the engine's operation into electric signals which then are amplified and sent to a cathode-ray tube where a characteristic pattern is produced on the screen. A 3-phase generator connected to the engine synchronizes the sweep of the oscilloscope with engine rotation. A rotary switch is used to select individual cylinders on a given engine for inspection, and a "condition-selector" switch is used for the selection of various phenomena occurring in the cylinder.

To display patterns of the ignition system, the changing voltage in the magneto switch in the primary circuit is applied directly without change or distortion to the vertical deflection circuit of the indicator. The connection is made through a resistor which isolates the analyzer from the ignition system.

For vibration patterns, the voltage generated by vibration pickups on the cylinders are amplified and applied to the vertical deflection circuit of the indicator. These patterns are exact replicas of all the noises in each cylinder. Each extraneous clank in the engine can be seen on the screen so that its cause and location in the engine can be determined.

Cylinders free from operating troubles show a characteristic pattern which can be taken as the normal pattern. Noticeable deviations from this normal pattern indicate trouble associated with the cylinder or spark plug under observation. As each kind of trouble produces a particular pattern change that is characteristic of the trouble, this deviation identifies the nature of the trouble. In this manner such troubles as short-circuited secondary circuit of the magneto, too small a spark-plug gap, fouled plugs, open secondary winding, large spark-plug gaps, breaker point bounce, magneto mistiming, short-circuited primary capacitors, lack of combustion in the cylinder, and engine roughness are identified readily.

High Current Generating Method Shown at Metals Exposition

A new method of creating high electric currents with relatively simple equipment was demonstrated at the National Metals Exposition in Chicago, Ill., October 18–25, 1947. The method is being developed by Progressive Welder Company, Detroit, Mich.

The new unit requires only an ordinary 15- or 25-horsepower motor. This motor drives a low-voltage generator to which is attached an extremely heavy flywheel. The system operates by using a small amount of power from an ordinary electric supply line to run the 3-phase 15-horsepower motor, and to store this energy up in the rapidly spinning flywheel. When the heavy load is applied, the generator, instead of stalling its drive motor under the overload, is kept turning by the energy of the flywheel, reconverting the mechanical energy back into electric current of the high intensity required. While this occurs, the flywheel slows down slightly, and as soon as the load is cut off again, the motor speeds up the flywheel,

restoring the energy consumed. The system was demonstrated, using a generator driven by a 15-horsepower motor to supply a flash welder on which two pieces of $1^1/_4$ inch diameter steel were welded together endwise. The slowing down of the flywheel was actually imperceptible to the ear, indicating the large amounts of power which can be stored in this manner. One of the devices that made possible the practical application of this power system is a simple new carbon-pile switch capable of controlling and interrupting the high currents delivered by the generator.

Mrs. L. S. Campbell Dies. A well-known worker in the technical educational field, Mrs. Laura S. Campbell died on October 24, 1947, after a short illness. She was director of the evening diploma school at Drexel Institute of Technology, Philadelphia, Pa. By virtue of her outstanding work in technical education, she had been elected to membership in the American Society for Engineering Education, the society's first and only woman member of the division on technical institutes.

RMA Releases Radiobroadcasting Statistics

Some interesting radiobroadcasting statistics were included in a statement by Paul A. Walker, acting chairman of the Federal Communications Commission, released by the Radio Manufacturers Association and the National Association of Broadcasters.

Commenting on the progress of the radio industry, Acting Chairman Walker pointed out that in the domestic broadcast picture, the number of licensed standard stations is approaching 1,500, with about one-fourth that number additionally under construction. Of the more than 1,000 frequency modulation stations licensed or authorized, more than 300 are on the air. Television outlets are nearing 70, and noncommercial educational stations approach 50 in number. Other types of broadcast stations and auxiliaries brings the broadcast total to well over 3,500.

In the nonbroadcast field the number of authorized stations approximates 40,000. These embrace safety and special services, including marine, aeronautical, police, fire, forestry, railroad, public utility, geological, experimental, and others.

The growth of radio stations is reflected in the number of commercial radio operators, which now exceeds 336,000. The amateur fraternity alone accounts for some 80,000 operators and 75,000 stations.

The number of radio stations, however, is not a complete measure of activity, inasmuch as, in some services, a single authorization can cover numerous mobile units. For example, about 25,000 radio-equipped vehicles are testing 2-way radiotelephone service. Short-distance radio communication services for industries and citizens appear to be just around the corner.

It also was pointed out that radio is being used to link isolated places with the telephone system. Coaxial cable and microwave relay are supplementing wire systems, besides holding promise for broadcast use.

Laboratories Established for Applied Mathematics

A federal center of applied mathematics —the National Applied Mathematics Laboratories—has been established as a division of the National Bureau of Standards, and Doctor John H. Curtiss has been named chief of the new division.

Organized to conduct research and provide services in the field of applied mathematics, the new organization is oriented around modern mathematical statistics as applied to the physical and engineering sciences and to the development and use of modern high-speed computing. The Applied Mathematics Laboratories include four separate laboratories: the Institute of Numerical Analysis; the Computation Laboratory; the Statistical Engineering Laboratory; and the Machine Development Laboratory.

The concept of such a center originated in 1946 in what is now the Office of Naval Research when it became apparent that there was a strong need for a centralized national computation facility, not only equipped with high-speed computing machinery, but able to contribute to the development of such equipment. Further co-operative study between the Bureau of Standards and the Office of Naval Research indicated that an organization wider in scope than a national computation center was needed. The development of high-speed tools for computation, for example, carried with it an obligation to perform research and conduct training in the theory and disciplines needed for the most effective use of these tools. From the standpoint of both government and private research and industrial processes, the final aim of such a center is to provide the economies and introduce the efficiencies which are possible when relatively inexpensive calculating is substituted for expensive trial-and-error experimentation.

Besides the four laboratories making up the organization, the work is carried on with the advice and guidance of a committee called the Applied Mathematics Council. The council is made up of representatives of government agencies and private organizations actively interested in the work of the unit.

THE FOUR LABORATORIES

The Institute of Numerical Analysis, headed by A. S. Cahn, has been located on the campus of the University of California at Los Angeles. The concentration in the Los Angeles area of technical industries and research institutions was the reason for its location there. The work of the institute is being underwritten for the next two years by the Office of Naval Research. Its primary function is to conduct research and training in the types of mathematics which are pertinent to the efficient exploitation and development of high-speed automatic digital computing machinery. It also provides an expert computing service for local groups and assists, when necessary, in the formulation and analysis of difficult problems in applied mathematics.

THE COMPUTATION LABORATORY

Like the institute, the Computation Laboratory is being underwritten by the Office of Naval Research. The mathematical tables project of the Bureau of Standards, which has been supported for some time on funds transferred from the Office of Naval Research and its predecessor, the Office of Research and Inventions, has been incorporated within the new laboratory. The unit is providing a general computing service of high quality and large capacity for use by private industry, Government agencies, educational and research institutions. It will continue to prepare and distribute mathematical tables and to formulate and analyze problems of the more routine type. This laboratory is headed by Doctor A. N. Lowan.

STATISTICAL ENGINEERING LABORATORY

The Statistical Engineering Laboratory, with Doctor C. Eisenhart as chief, provides a general consulting service on the methods of modern statistical inference as applied to the engineering and physical sciences. This work is being carried on not only for the other divisions in the Bureau of Standards but also for the Federal Specifications Board, other Government agencies, and private organizations. The laboratory also is providing training in the theory of statistics and assisting in the formulation of requirements for mathematical tables and other aids for the application of statistics.

MACHINE DEVELOPMENT LABORATORY

The Machine Development Laboratory is in charge of the development and construction of computing machines which will meet performance specifications established by the operating units of the Applied Mathematics Laboratories, the Office of Naval Research, the Bureau of the Census, and other Government agencies. At the present time it is setting up the mathematical specifications for two high-speed-electronic computers being constructed through the Bureau of Standards for the Office of Naval Research and the Bureau of the Census at a cost of $300,000 each. This organization is responsible for the co-ordination of mathematicians, electronics engineers, and physicists who must co-operate to produce this revolutionary equipment. When completed, one of the machines will be installed at the Institute of Numerical Analysis, allowing an expansion of the work both in research and service carried on there. Doctor E. W. Cannon is in charge of this laboratory.

H. S. Black Dies. Senior vice-president and a member of the board of directors of the Ohio Brass Company, Mansfield, Ohio, Harry S. Black died suddenly at his home in Mansfield on October 9, 1947, after a brief illness. He joined the Ohio Brass Company in 1898, ten years after it was founded. In 1902 he was elected treasurer of the company and held this position until 1919 when he was elected vice-president. In 1928 he was made senior vice-president, the position he held at the time of his death.

OTHER SOCIETIES

SMPE Holds Meeting in New York, October 20-24

The Society of Motion Picture Engineers' 62d semiannual convention was held at the Hotel Pennsylvania, New York, N. Y., October 20–24, 1947. A number of interesting technical papers were presented, covering a wide range of subjects related to theater operation as well as motion picture production.

An interesting highlight of the convention was a theater television session. Among the subjects discussed were the development of theater television in England, the general analysis of theater television, the activities of the SMPE in theater television, optical problems, and new developments in large screen television. A demonstration of large screen television by the Radio Corporation of America was shown on a screen six by eight feet in size.

SYNTHENIC SOUND ON FILM

Robert E. Lewis, of the Armour Research Foundation at Illinois Institute of Technology, and Norman McLaren of the National Film Board of Canada, presented an interesting paper on synthetic sound on film. The hand-drawn or machine-made film sound track was described as a tool of unique value to the composer, enabling him to hear his composition as written, rather than through another artist's interpretation; as a scientific tool for experimentation and research in the nature of sound relations; and as the means of synthesizing test film without conventional recording errors. Methods of achieving sound animation includes drawing the sound directly on the film, frame-by-frame exposure of drawings previously produced by hand, and synthesizing wave forms by means of sine-wave generators.

While variations in tone and combinations of tone may be determined by the form of the synthetic sound track, changes in volume may be introduced by using ink of different colors. Using blue writing ink in place of black India ink results in a definitely quieter sound, depending on the color sensitivity of the reproducing photoelectric-cell surface. Thus, by the use of colored ink it is possible to draw a passage which will reproduce differently according to the color response of the system. It is possible to control the volume of each sound, and thus remove a "green" tone, for instance, by insertion of a red filter, while leaving the "red" tones at full modulation.

GOLD MEDAL AWARDED

John A. Maurer, pioneer in the development of 16-millimeter sound recording equipment and techniques, received the first Samuel L. Warner Memorial Award. The gold medal award, established by Warner Brothers to be presented annually by the SMPE for outstanding work in sound motion picture engineering, commemorates the 20th anniversary of the death of Samuel L. Warner. J. A. Maurer was a leader in the co-operative efforts of the SMPE and the American Standards Association in preparing war Standards in the field of motion pictures for the Armed Forces during the war, and he designed and built a specialized 16-millimeter recording machine for the manufacture of test films to complement the Standards which he had helped to prepare.

NEW OFFICERS ELECTED

Several new national officers of the society were elected at business sessions. These incuded James Frank, Jr., of National Theater Supply, who was elected financial vice-president; Ralph B. Austrian, of Foote, Cone, and Belding, advertising, as treasurer; and John A. Maurer was re-elected as engineering vice-president. The new national officers will take office in January 1, 1948.

An innovation of the convention was an educational scientific exhibit with more than 50 manufacturers and other firms displaying the latest developments in heater equipment, structural materials, and supplies.

Mechanical Engineers Elect National Officers

E. G. Bailey, vice-president of The Babcock and Wilcox Company, New York, N. Y., has been elected the next national president of The American Society of Mechanical Engineers. Four regional vice-presidents and three directors-at-large also have been chosen.

National letter balloting by the membership closed in September. Nominations were made last June. The new offices will be assumed at the end of the 1947 annual meeting, to be held in Atlantic City, N. J., December 1–5, 1947.

Mr. Bailey, who succeeds Eugene W. O'Brien of Atlanta as president of the ASME, is noted as an authority on fuels, combustion, and power developments. He is an inventor in the combustion field, with more than 100 United States patents. His home is in Easton, Pa.

The regional vice-presidents elected are: Frank M. Gunby, associate of Charles T. Main, Inc., Boston, Mass.; Paul B. Eaton, head of the mechanical engineering department of Lafayette College, Easton, Pa.; Thomas E. Purcell, general superintendent of power stations, Duquesne Light Company, Pittsburgh, Pa.; J. Calvin Brown, head of the engineering firm of J. Calvin Brown, Los Angeles, Calif.

IRE Elects Shackelford President for 1948 Term

Benjamin E. Shackelford (M '42) manager of the license department of the Radio Corporation of America's international division, New York, N. Y., has been elected president of the Institute of Radio Engineers for the year 1948 (*p 1253*). Doctor Reginald L. Smith-Rose, superintendent of the radio division, National Physical Laboratory, Teddington, Middlesex, England, has been chosen vice-president. Doctor Shackelford has been a Fellow of the IRE since 1938, and Doctor Smith-Rose since 1944.

For director-at-large for the 1948–50 term, the following were elected: James

Future Meetings of Other Societies

American Institute of Mining and Metallurgical Engineers. Annual meeting, February 15–19, 1948, New York, N. Y.

American Society of Refrigerating Engineers. Winter meeting, December 7–10, 1947, Atlantic City, N. J.

American Society of Mechanical Engineers. Annual meeting, December 1–5, 1947, Atlantic City, N. J.

American Society for Testing Materials. Spring meeting and committee week, March 1–5, 1948, Washington, D. C.; Annual meeting, June 21–25, 1948, Detroit, Mich.

Canadian Institute of Radio Engineers. Convention, April 30–May 1, 1948, Toronto, Ontario, Canada.

CIGRE (International Conference on Large Electric High-Tension Systems). Biennial meeting, June 24–July 3, 1948, Paris, France.

Exposition of Chemical Industries. 21st annual exposition, December 1–5, 1947, New York, N. Y.

Institute of Radio Engineers. Annual convention and radio engineering show, March 22–25, 1948, New York, N. Y.

Midwest Power Conference. Annual meeting sponsored by Illinois Institute of Technology, April 7–9, 1948, Chicago, Ill.

National Association of Corrosion Engineers. Annual conference and exhibition, April 5–8, 1948, St. Louis, Mo.

National Association of Manufacturers. 52d Annual Congress of American Industry, December 3–5, 1947, New York, N. Y.

National Electrical Manufacturers Association. Winter convention, March 14–18, 1948, Chicago, Ill.

National Materials Handling Exposition. January 12–16, 1948, Cleveland, Ohio.

National Society of Professional Engineers. December 4–6, 1947, Buffalo, N. Y.

Refrigeration Equipment Manufacturers Association. All-Industry Refrigerating and Air-Conditioning Exposition. January 26–29, 1948, Cleveland, Ohio.

E. Shepherd (M '44) research engineer, Sperry Gyroscope Company, Inc., Great Neck, N. Y.; and Doctor Julius A. Stratton, professor of physics and director of the research laboratory of electronics, Massachusetts Institute of Technology, Cambridge.

Also elected at this time were the following regional directors:

North Atlantic region (1)—Herbert J. Reich (M '43) professor of electrical engineering, Dunham laboratory, Yale University, New Haven, Conn.

North Central Atlantic region (2)—John V. L. Hogan (M '20) president, Radio Inventions, Inc., and Faximile, Inc., New York, N. Y.

Central Atlantic region (3)—John B. Coleman (A '25) assistant director of engineering, RCA division, Radio Corporation of America, Camden, N. J.

East Central region (4)—John A. Hutcheson, associate director of research, Westinghouse Electric Corporation, East Pittsburgh, Pa.

Central region (5)—John A. Hunter, president, Hunter Manufacturing Company, Iowa City, Iowa, and staff consultant, psychology department, University of Iowa

Southern region (6)—A. Earle Cullum, Jr., consultant radio engineer, Dallas, Tex.

Pacific region (7)—Frederick E. Terman (F '45) dean of the school of engineering, Stanford University, Calif.

Canadian region (8)—Frederick S. Howes, associate professor of electrical engineering and consulting engineer, McGill University, Montreal, Quebec, Canada

Industrial Research Institute Meets in Niagara Falls, Canada

The fall meeting of Industrial Research Institute, Inc., was held September 25–26, 1947, at Niagara Falls, Ontario, Canada, with guest speakers from British and Canadian institutions. E. K. Rideal, director, Royal Institution, London, England, discussed the structure of British research at an informal dinner session Thursday evening. The following day, R. R. McLaughlin, head, chemical engineering department, University of Toronto, outlined the relationship of industrial, government, and university research in Canada, and expressed his views as to the effect of these activities on the long term development of science.

The meeting opened on Thursday morning with a session on subjects of special interest to industrial research management. H. N. Stephens, research director, Minnesota Mining and Manufacturing Company, St. Paul, Minn., discussed the basic problems of research direction with emphasis on maintaining morale in the organization. A. S. Davis, Jr., resident attorney, Research Corporation, New York, N. Y., discussed patent policies for industrial research and how such policies should be set up and administered. Budgeting for research and development was the subject of a talk by J. M. McIlvain, director, administrative division, research and development department, Atlantic Refining Company, Philadelphia, Pa.

Thursday afternoon was devoted to several round-table discussions on the subject of developing helpful relations within the research laboratory, between the research worker and management, and between the industrial research laboratory and the universities. The 130 men in attendance were divided into small groups which permitted full and free discussion of the subjects.

The meeting closed on Friday afternoon with inspection tours of the Cornell aeronautical laboratory, Buffalo, N. Y., and the Union Carbide and Carbon research laboratories, Niagara Falls, N. Y.

New PEI Officers. During the 16th annual meeting of the Porcelain Enamel Institute, held October 9 at the Hotel Cleveland, Cleveland, Ohio, the following institute officers were elected for the coming year: *president*, C. D. Clawson, Ferro Enamel Corporation, Cleveland, Ohio (R. H. Turk, Pemco Corporation, Baltimore, Md., retiring); *vice-presidents*, Herbert R. Spencer, The Erie Enameling Company, Erie, Pa.; Edward L. Seasholtz, J. M. Seasholtz and Sons Company, Reading, Pa.; R. J. Ritchey, Carnegie-Illinois Steel Company, Pittsburgh, Pa.; J. T. Penton, California Metal Enameling Company, Los Angeles, Calif.; J. H. E. McMillan, Ingram-Richardson Manufacturing Company, Beaver Falls, Pa.; *treasurer*, P. B. McBride, Porcelain Metals Corporation, Louisville, Ky.; *secretary*, Edward Mackasek, Porcelain Enamel Institute, Washington, D. C. The 16th annual meeting of the Institute was followed by a sales and management conference on October 10.

1948 Lighting Conference. A. H. Manwaring, chairman of the Illuminating Engineering Society conference committee, announced at the annual meeting of the society that the 1948 National IES Technical Conference will be held at the Hotel Statler in Boston, Mass., September 20–24, 1948. Next year's meeting will feature presentation of technical papers on lighting, lamps, and related subjects by experts from all parts of the United States and Canada. More than 25 lighting specialists from England, Canada, Cuba, and South America attended the 1947 conference held in New Orleans, La., during the week of September 15th. It is hoped that improved conditions will permit the attendance of an even greater number of foreign delegates next year.

Chicago Production Show Planned for March, 1948

Plans for the 1948 Chicago Production Show to be held March 22–24, 1948, at the Stevens Hotel, Chicago, Ill., have been announced by Paul A. Jenkins, executive secretary of the Chicago Technical Societies Council, sponsor of the show and the concurrent Chicago Technical Conference.

Attendance at the conference next March is expected to reach 10,000; attendance at the concurrent show is expected to exceed 25,000. These twin events are an outgrowth of the war production clinics inaugurated in 1943 by the War Production Board in major cities of the United States.

Attended largely by production executives of Chicago and the Middle West, the Chicago Production Show is an annual exhibit of materials, tools, instruments, handling equipment, and services designed to increase production volume and decrease production costs.

As in previous years, the 1948 Chicago Production Show will accommodate about 140 exhibitors. Booth space now is being offered and firms desiring to participate may direct their inquiries to Mr. Jenkins at the Chicago Technical Societies Council, 53 West Jackson Boulevard, Chicago 4, Ill.

Bell PCM System Demonstrated at IRE Meeting

A system of pulse modulation known as PCM (pulse code modulation) was demonstrated at a meeting of the New York section of the Institute of Radio Engineers on October 1, 1947, in the auditorium of the Engineering Societies building. Developed by engineers of the Bell Telephone Laboratories, PCM is expected to be used for long distance telephone transmission by providing freedom from noise and interference. It is especially applicable to microwave radio relay circuits.

The demonstration was given by L. A. Meacham and Eugene Peterson (M '26) of Bell Telephone Laboratories, both of whom have been active in the development of the system. The coding tube, a new vacuum tube which converts the human voice into patterns or codes, was described by R. W. Sears, also of the Bell Telephone Laboratories technical staff, who designed and developed it for use in the system.

Pulse modulation, or sampling, is so named because the continuous speech wave is sampled very briefly and rapidly and only information regarding these samples is transmitted. PCM accomplishes this by using a set of patterns or codes, each one of which conveys specific information about the sample which it represents. Each of the patterns consists of an arrangement of electric pulses which always contains a definite and constant number of pulses. These pulses are either "on" or "off," that is, present or absent. Thus, as long as these groups of simple on-off pulses are received properly, speech sent over PCM is reproduced perfectly.

A new type of vacuum tube is used in this system. Its function is to convert the human voice electronically into patterns or codes. All the 128 codes available in the seven pulse code group are perforated in appropriate order in a special plate which is placed inside a modified cathode-ray tube. This plate is placed between the electron gun and the target plate in such a manner that a beam of

electrons can sweep across the seven elements of any one code group. Which one it actually sweeps across is determined by the position of the beam, and this in turn is determined by the amplitude of the signal at the time of sampling.

If the beam goes through a hole in the perforated plate, the pulse is an "on" pulse; if the beam is blocked because there is no perforation at that point, it is an "off" pulse. The irregular pattern of "on" and "off" pulses carries the information concerning the amplitude sample to the receiving station.

Both speech and music were sent over the new system and reproduced through loud-speakers in the auditorium. Though the new system is expected to be used primarily as an adjunct to the telephone network, it also can be used to transmit radio programs, pictures, and teletype-writer signals.

Large-Screen Television Demonstrated at Convention

An intercity television network employing a chain of microwave relays carried daily television programs over a distance of about 200 miles for demonstrations of large-screen projection television during the annual convention of the National Association of Broadcasters in Atlantic City, N. J. The demonstrations, showing pictures six by eight feet in size, were presented co-operatively by the American Broadcasting Company, the National Broadcasting Company, their affiliates *WFIL-TV* and *WPTZ*, and the RCA Victor division of the Radio Corporation of America. The broadcasting companies supplied the television program and RCA provided the equipment and the facilities.

The programs originated in New York and were beamed to the shore resort by way of Philadelphia, Pa. Six relay units were used to relay the programs from *WNBT* atop the Empire State Building, to Atlantic City.

The experimental model large-screen television projector used in the demonstrations employed a system of reflective optics developed by RCA, and a special new projection-type cathode-ray picture tube coated with extremely brilliant phosphors. The optical system of the projector consisted of two elements—a 21-inch spherical mirror and a 14-inch aspherical correcting lens mounted vertically in a tubular housing. The 17-inch, metal-backed, high-intensity developmental projection tube is placed in such a position that its face is directed toward the magnifying spherical mirror, which is pointed at the projection screen. The large spherical reflector greatly magnifies the picture picked up from the face of the projection tube and projects it through the 14-inch aspherical lens to the beaded screen.

The use of a spherical reflective lens with a large aperture introduces difficulties in focusing and results in a certain amount of distortion. For this reason the specially-ground weak aspherical correcting lens is used to introduce an amount of distortion which is equal to and opposite that caused by the mirror. The effect of the aspherical lens is to balance out the distortion of the reflective lens and the rays of light arriving at the screen produce an undistorted and greatly enlarged version of the original picture, six by eight feet in size. An extremely high acceleration voltage is required for the projection tube in order to obtain light of proper brilliance for projection. In this instance 50,000 volts is used.

A high-frequency oscillator power supply is used instead of the conventional 60-cycle type, which prevents the storage of high voltage in the filter circuits, and thus eliminates the potential hazard to operating personnel.

RESEARCH.....

Applications Now Accepted for GE Scholarships

Aid to college and university graduates who wish to undertake or continue research work in scientific and industrial fields has been announced by the General Electric Company for the 24th consecutive year.

Applications now are being accepted for the scholastic year 1948–1949 for grants under the $1,000,000 GE Educational Fund, from the income of which the fellowships are awarded.

The Educational Fund was established in honor of two former General Electric presidents. The Charles A. Coffin Foundation, named for the company's founder and first president, and the Gerard Swope Foundation, provide more than $15,000 annually for research fellowships. Since 1923, when the Coffin Foundation was established, 179 awards totaling $129,000 have been granted 147 individuals.

Applications for the fellowships, which must be filed by January 1, 1948, have been distributed to libraries of engineering schools, department heads of electrical and mechanical engineering schools, professors of electrical and mechanical engineering, physics, chemistry, and metallurgy, and deans of graduate schools.

The Charles A. Coffin fellowships are awarded in the fields of electricity, physics, and physical chemistry. The Gerard Swope fellowships, first granted in 1946, are awarded in fields of industrial management, engineering, physical sciences, and any other scientific or industrial field.

Individual fellowships will be for the amount needed up to a maximum of $1,500 annually for each individual. A grant of $500 may be made for specific apparatus or other expense in connection with the research work. In addition, in case of need, loans up to $1,000 also may be made.

Fellowships are intended for graduates who need financial assistance, and who have shown by the character of their work that they, with advantage, could undertake or continue research work in educational institutions either in the United States or abroad. They are not intended for graduates who now hold, or expect to hold, any other fellowship which carries a stipend larger than the tuition at the institution where the research work is to be done.

Applications, which may be obtained from A. D. Marshall, secretary, General Electric Educational Fund, Schenectady, N. Y., will be passed on by a committee representing the National Academy of Sciences, American Chemical Society, American Physical Society, AIEE, the American Society of Mechanical Engineers, and the American Society for Engineering Education.

Institute of Numerical Analysis Established in California

The National Bureau of Standards has completed plans for the establishment of the Institute of Numerical Analysis at the University of California at Los Angeles. The institute will have two primary functions. The first is research in applied mathematics aimed at developing methods of analysis which will extend the use of high-speed electronic computers. The second is to act as a service group for western industries, research institutions, and government agencies.

The service function will include not only the use of the machines for problem solving, but also assistance in the formulation of problems in applied mathematics of the more complex and novel types. Service operations are to be initiated immediately using the latest types of commercially available computing equipment.

One of the giant high-speed electronic computing machines now under development by the National Bureau of Standards will be installed at the institute when completed. These computers will solve problems in minutes that now take days to work out, and will solve in days problems that are now out of the reach of scientists.

The University of California was selected as the site for the institute after a nation-wide survey by the National Bureau of Standards. It was decided that Los Angeles offered the widest range of possibilities for an Institute of Numerical Analysis because of the concentration of aircraft industries and the presence of several major scientific institutions in that area.

Servomechanism Research Announced by Yale

Two new research projects dealing with hydraulic valve systems which are elements of servomechanism systems have been announced by Yale University. The valve systems have wide applications in controlling airplane guns, the control surfaces of airplanes, and guided missiles.

With announcement of these new

projects, the Yale department of electrical engineering now has four research contracts in progress in conjunction with the General Electric Company, the organization responsible for a large guided missile program under the United States Army Ordnance Department. Two of the projects are based on servomechanism control by hydraulic means.

The hydraulic systems possess many advantages over other means of control. Because the fluids which are used in hydraulic systems cannot be compressed readily, an exceedingly fast response is obtained. Hydraulic devices now commonly are employed in guided missiles because they occupy less space and have less weight than other control devices. The Yale research is concerned with improving the accuracy and speed of response of these controls.

One of the investigations in the Dunham laboratory of electrical engineering is theoretical in nature and concerns the irregular characteristics of throttling valves in the servomechanisms. This research is under Associate Professor John L. Bower and Assistant Professors Felix Zweig and W. Jack Cunningham.

A second major project concerns theoretical and experimental studies of electrically driven hydraulic valve systems under Professor Bower and James G. Clarke, of the department of electrical engineering, and Joseph S. DiRende, instructor in mechanical engineering.

These researches at Yale University tie in directly with the graduate educational and research programs instituted by the department of electrical engineering more than a year ago in the field of servomechanisms.

Conference Held on Administration of Research

A conference on the administration of research was held at the Pennsylvania State College, October 6 and 7, 1947. The conference was sponsored by the school of engineering of the Pennsylvania State College, and was attended by 200 leaders of research management from laboratories in the United States and Canada. Laboratories both large and small, managed by industry, educational institutions, and governmental agencies, were represented.

Following registration, the Monday morning meeting was called to order by Dean Hammond of the school of engineering of the Pennsylvania State College who, after a brief introductory talk, introduced Doctor J. A. Hutcheson, associate director, research laboratories, Westinghouse Electric Corporation, who was chairman of the Monday morning session. Speakers at this session were Maurice Holland (M '30) industrial research adviser, New York, N. Y.; Doctor R. L. Jones (F '31) vice-president, Bell Telephone Laboratories; and Doctor G. H. Young, assistant director, Mellon Institute of Industrial Research.

M. Holland spoke on "The Place of Research in the Corporate Structure." The subject of the talk by Doctor Jones was "Organization by Scientific Division" and this was followed by "Organization by Individual Projects" by Doctor Young.

The meeting Monday afternoon was led by Doctor Philip M. Morse as chairman. Doctor Morse is the director of Brookhaven National Laboratories. "Research Reports—Their Form and Usefulness" was the subject of a paper by Doctor Dwight E. Gray, editor, applied physics laboratory, Johns Hopkins University. Doctor L. Warrington Chubb (F '21) director, research laboratories, Westinghouse Electric Corporation presented a paper "Inventions and Patent Policy." "Policy on Publications" was the subject of a talk by Doctor Edward U. Condon (M '44) director, National Bureau of Standards.

The dinner speaker at the meeting Monday evening was Colonel Leslie E. Simon, director, Ballistics Research Laboratories, Aberdeen Proving Ground, who spoke on "German Research in World War II" from personal investigation of German research laboratories made since the war.

The chairman of the session Tuesday morning was Doctor Jesse E. Hobson (M '41) director, Armour Research Foundation. The first paper on the program at this meeting was one by Commodore Henry A. Schade, director, Naval Research Laboratory, on "Inception and Development of a Research Project." Doctor Blaine B. Wescott, Gulf Research and Development Company, presented a paper, "Analyses of Research Costs." Doctor Paul D. Foote, executive vice-president, Gulf Research and Development Company, used Doctor Wescott's presentation as a basis for a further discussion of "Analyses of Research Costs." "Selection and Training of Research Personnel" was the subject of Doctor Albert W. Hull, assistant director, research laboratories, General Electric Company.

Proceedings of this conference will be published as soon as possible. The price is $3. Copies of these proceedings may be ordered from professor Kenneth L. Holderman, Pennsylvania State College, State College, Pa.

JOINT ACTIVITIES

A. B. Kinzel Re-elected Engineering Foundation Head

The Engineering Foundation re-elected Doctor A. B. Kinzel, vice-president of the Union Carbide and Carbon Research Laboratories, Inc., as its chairman at the annual meeting of its board of directors in the Engineering Societies Building, 29 West 39th Street, October 16, 1947. Other officers who were re-elected included: Doctor L. W. Chubb (F '21) director of the Westinghouse research laboratories, as vice-chairman; Doctor Edwin H. Colpitts (F '12) formerly vice-president of the Bell Telephone Laboratories, as director; and John H. R. Arms, secretary.

Members newly appointed to the executive committee were George L. Knight (ASME), formerly vice-president of the Brooklyn Edison Company; and Doctor Joseph W. Barker (AIEE, F '30), president of the Research Corporation and former dean of engineering, Columbia University. Others to continue their terms on the executive committee are Doctor Kinzel as chairman, J. H. R. Arms as secretary; also Doctor O. E. Buckley (AIEE, F '29) president of the Bell Telephone Laboratories; and R. H. Chambers (ASCE) former vice-president and consulting engineer of the Foundation Company.

The research procedure committee again will be headed by Doctor Chubb, 1946 winner of the John Fritz Medal and certificate. Other members will be Doctor Boris A. Bakhmeteff (ASCE) consulting engineer and professor of civil engineering, Columbia University; Frank F. Colcord (AIME) vice-president and manager of metal sales, United States Smelting Refining and Mining Company, and Doctor J. F. Downie Smith (ASME) dean of engineering, Iowa State College.

RESEARCH PROJECTS AIDED

Reports were made at the meeting on 13 research projects aided by the Engineering Foundation during the past year. These projects were concerned with studies in such varied fields as alloys of iron, metal cutting, welding, properties of gases, riveted and bolted structural joints, hydraulics, and soil mechanics.

Grants were recommended for the year 1947–1948 for the continuation of nine of the past year's 13 projects, and for the support of eight new projects.

The Engineering Foundation has been engaged in important research activities for more than 30 years. It aided in establishing the National Research Council and its Division of Engineering and Industrial Research. It has contributed to the support of the Engineers' Council for Professional Development, which, representing some eight engineering organizations, aims at the advancement of the profession of engineering. The foundation has supported engineering research and investigations in such fields as arch dams for power development, arch and column design, thermal properties of steam, stability of steels as affected by temperature, plastic flow of metals, cotton seed processing, dielectrics and power cable insulation, and many other fields.

In the selection of research projects to be supported, preference has been given to those of a more fundamental nature which would not be undertaken by an industrial research organization. Where projects are of interest to a group of industries, the foundation has provided a limited financial support and a sponsorship intended to enable the principal support of the project to be secured from interested industries and other sources.

List of Undergraduate Engineering Curricula Accredited by ECPD as of October 24, 1947*

(Subject to periodic revision)

Akron, University of: Electrical[c], mechanical (industrial and aeronautical options)[e]

Alabama Polytechnic Institute: Civil, electrical, mechanical

Alabama, University of: Aeronautical, civil, electrical, industrial, mechanical, mining

Alaska, University of: Civil, mining (including metallurgical and geological options)

Arizona, University of: Civil, electrical, mechanical, mining

Arkansas, University of: Civil, electrical, mechanical

Brooklyn, Polytechnic Institute of: Chemical (day and 8-year evening), civil[a], electrical[a], mechanical[a]

Brown University: Civil, electrical, mechanical

Bucknell University: Chemical, civil, electrical, mechanical

California Institute of Technology: Aeronautical (5- and 6-year courses), chemical (5-year course), civil, electrical, mechanical

California, University of: Civil, electrical, mechanical, metallurgical (metallurgy), mining, petroleum

Carnegie Institute of Technology: Chemical[c-r], civil[a], electrical[a,c-r], industrial (management)[a,c-r], mechanical[a,c-r], metallurgical[a,c-r]

Case Institute of Technology: Chemical, civil, electrical, mechanical, metallurgical

Catholic University of America: Aeronautical, architectural, civil, electrical, mechanical

Cincinnati, University of: Aeronautical[a], chemical[a], civil[a], electrical[a], mechanical[a]

Citadel, The: Civil

Clarkson College of Technology: Chemical, civil, electrical, mechanical

Clemson Agricultural College: Civil, electrical, mechanical

Colorado School of Mines: Geological, metallurgical, mining, petroleum

Colorado State College: Civil, electrical, mechanical

Colorado, University of: Architectural, civil, electrical, mechanical (includes aeronautical option)

Columbia University: Chemical[b], civil[b], electrical[b], industrial[b], mechanical[b], metallurgical[b], mining[b]

Connecticut, University of: Civil, electrical, mechanical

Cooper Union School of Engineering: Chemical[d], civil[d], electrical[d], mechanical[d]

Cornell University: Chemical, civil, electrical, industrial (administrative), mechanical

Dartmouth College: Civil

Delaware, University of: Chemical, civil, electrical, mechanical

Denver, University of: Electrical

Detroit, University of: Aeronautical[c-r], architectural[c-r], chemical[c-r], civil[c-r], electrical[c-r], mechanical[c-r]

Drexel Institute of Technology: Chemical[c-r], civil[c-r], electrical[c-r], mechanical[c-r]

Duke University: Civil, electrical, mechanical

Florida, University of: Chemical, civil, electrical, industrial, mechanical

George Washington University: Civil, electrical, mechanical

Georgia School of Technology: Aeronautical, ceramic[c-r], chemical (including co-operative curriculum)[c-r], civil[c-r], electrical[c-r], mechanical[c-r]

Harvard University[g]: Civil, communication, electrical, industrial (engineering and business administration), mechanical, metallurgical (physical metallurgy), sanitary

Idaho, University of: Civil, electrical, mechanical, metallurgical (metallurgy), mining (includes geographical option)

Illinois Institute of Technology (Armour College of Engineering)[g]: Chemical, civil, electrical, mechanical

Illinois, University of: Architectural, ceramic (technical option), chemical, civil, railway civil, electrical, railway electrical, general[f], mechanical, railway mechanical, metallurgical, mining

Iowa State College: Agricultural, architectural, ceramic, chemical, civil, electrical, general[f], mechanical

Iowa, State University of: Chemical, civil, electrical, mechanical

Johns Hopkins University: Chemical, civil, electrical, mechanical

Kansas State College: Agricultural, architectural, civil, electrical, mechanical

Kansas, University of: Architectural, civil, electrical, mechanical, mining

Kentucky, University of: Civil, electrical, mechanical, metallurgical, mining

Lafayette College: Civil, electrical, industrial (administrative), mechanical, metallurgical, mining

Lehigh University: Chemical, civil, electrical, industrial, mechanical, metallurgical, mining

Louisiana State University: Chemical, civil, electrical, mechanical, petroleum

Louisville, University of: Chemical[c-r], civil[c-r], electrical[c-r] mechanical[c-r]

Maine, University of: Civil, electrical, general[f], mechanical

Manhattan College: Civil, electrical

Marquette University: Civil[a], electrical[a], mechanical[a]

Maryland, University of: Chemical, civil, electrical, mechanical

Massachusetts Institute of Technology: Aeronautical, building and construction, chemical, civil (includes option in sanitary engineering), electrical[c-r], general[f], industrial (business and engineering administration), mechanical[c-r], metallurgical (metallurgy), naval architecture and marine engineering (including marine transportation)

Michigan College of Mining and Technology: Chemical, civil, electrical, mechanical, metallurgical, mining

Michigan State College: Civil, electrical, mechanical

Michigan, University of: Aeronautical, chemical, civil, electrical, engineering mechanics, mechanical, metallurgical, naval architecture and marine engineering, transportation

Minnesota, University of: Aeronautical, chemical, civil, electrical, mechanical, metallurgical, mining, petroleum

Mississippi State College: Civil, electrical, mechanical

Missouri School of Mines and Metallurgy: Ceramic, civil, electrical, metallurgical, mining (mine) (including petroleum option)

Missouri, University of: Chemical, civil, electrical, mechanical

Montana School of Mines: Geological, metallurgical, mining

Montana State College: Civil, electrical, mechanical

Nebraska, University of: Agricultural, architectural, civil, electrical, mechanical

Nevada, University of: Electrical, mechanical, mining

New Hampshire, University of: Civil, electrical, mechanical

New Mexico College of Agriculture and Mechanic Arts: Civil, electrical, mechanical

New Mexico School of Mines: Geological, mining, petroleum

New Mexico, University of: Civil, electrical, mechanical

New York, College of the City of: Civil[a], electrical[a], mechanical[a]

New York State College of Ceramics (at Alfred University): Ceramic

New York University: Aeronautical, chemical (day and 7-year evening), civil[a], electrical[a], industrial (administrative), mechanical[a]

Newark College of Engineering: Civil[c-r], electrical[c-r], mechanical[c-r]

North Carolina State College: Ceramic, civil, electrical, mechanical

North Dakota Agricultural College: Architectural, mechanical

North Dakota, University of: Civil, electrical, mechanical, mining

Northeastern University: Chemical[a], civil[a], electrical[a], industrial[a], mechanical[a]

Northwestern University: Chemical, civil, electrical, mechanical

Norwich University: Civil, electrical

Notre Dame, University of: Aeronautical, civil, electrical, mechanical, metallurgical (metallurgy)

Ohio State University: Ceramic, chemical, civil, electrical, industrial, mechanical, metallurgical, mining (mine)

Oklahoma Agricultural and Mechanical College: Civil, electrical, industrial, mechanical

Oklahoma, University of: Architectural, chemical, civil, electrical, mechanical, petroleum

Oregon State College: Chemical, civil, electrical, mechanical

Pennsylvania State College: Architectural, ceramic (ceramics), chemical, civil, electrical, fuel technology, industrial, mechanical, metallurgical (metallurgy), mining, petroleum and natural gas, sanitary

Pennsylvania, University of: Chemical, civil, electrical, mechanical

Pittsburgh, University of: Chemical[c-r], civil[c-r], electrical[c-r], industrial[c-r], mechanical, metallurgical[c-r], mining[c-r], petroleum[c-r]

Pratt Institute: Electrical, mechanical

Princeton University: Chemical, civil, electrical, mechanical

Purdue University: Aeronautical, chemical, civil, electrical, mechanical, metallurgical

Explanatory Notes

* With the exception of the chemical engineering curricula, this list is corrected to October 24, 1947, and is subject to continual revision. It applies only to curricula which have been inspected by the committee on engineering schools, whether conducted on the usual plan of operation or on the accelerated plan. At the request of the council of the American Institute of Chemical Engineers, due to the effects of the war upon education in chemical engineering, all accrediting of chemical engineering curricula ceased with the 1943 list. Until such time as reasonably normal educational activities in the chemical engineering fields have been resumed and re-examinations made, no current list for this division of engineering will be published.

(*a*). Accrediting applies to the day and evening curricula.

(*b*). Accrediting applies to the 4-year and 5-year curricula leading to the bachelor of science degree.

(*c*). Accrediting applies to the co-operative curriculum only.

(*c-r*). Accrediting applies to both the co-operative and regular curricula.

(*d*). Accrediting applies to day and to 6-year evening curricula in the Cooper Union School of Engineering as submitted to ECPD.

(*e*). Accrediting applies only to curriculum as submitted to ECPD and upon completion of which a certificate is issued by Harvard University certifying that the student has pursued such a curriculum.

(*f*). The accrediting of a curriculum in general engineering implies satisfactory training in engineering sciences and in the basic subjects pertaining to several fields of engineering; it does not imply the accrediting, as separate curricula, of those component portions of the curriculum such as civil, mechanical, or electrical engineering that usually are offered as complete professional curricula leading to degrees in these particular fields.

(*g*). On July 24, 1940, Illinois Institute of Technology was formed by the consolidation of Armour Institute of Technology and Lewis Institute. Curricula now listed under Illinois Institute of Technology were listed under Armour Institute of Technology before October 24, 1940.

List of Undergraduate Engineering Curricula Accredited by ECPD as of October 24, 1947 (continued)

Rensselaer Polytechnic Institute: Aeronautical, chemical, civil, electrical, industrial, mechanical, metallurgical

Rhode Island State College: Civil, electrical, mechanical

Rice Institute: Chemical, civil, electrical, mechanical

Rochester, University of: Chemical, mechanical

Rose Polytechnic Institute: Civil, electrical, mechanical

Rutgers University: Civil, electrical, mechanical, sanitary

Santa Clara, University of: Civil, electrical, mechanical

South Carolina, University of: Civil, electrical

South Dakota State College: Civil, electrical, mechanical

South Dakota State School of Mines: Civil, electrical, general[1], metallurgical, mining

Southern California, University of: Civil, electrical, mechanical, petroleum

Southern Methodist University: Civil[2-7], electrical[2-7], mechanical[2-7]

Stanford University: Civil, electrical, mechanical, metallurgical, mining, petroleum

Stevens Institute of Technology: General[1]

Swarthmore College: Civil, electrical, mechanical

Syracuse University: Chemical, civil, electrical, industrial (administrative), mechanical

Tennessee, University of: Chemical, civil, electrical, mechanical

Texas, Agricultural and Mechanical College of: Aeronautical, chemical, civil, electrical, mechanical, petroleum (4- and 5-year courses)

Texas College of Mines and Metallurgy: Mining (mining option, mining geology, metallurgy option)

Texas Technological College: Civil, electrical, mechanical

Texas, University of: Architectural, chemical, civil, electrical, mechanical, petroleum (petroleum production)

Toledo, University of: General[2-7]

Tufts College: Civil, electrical, mechanical

Tulane University of Louisiana: Civil, electrical, mechanical

Tulsa, University of: Petroleum (including options in refining and production)[2-7]

Union College: Civil, electrical

United States Coast Guard Academy: General[1]

Utah State Agricultural College: Civil

Utah, University of: Civil, electrical, mechanical, metallurgical, mining

Vanderbilt University: Civil, electrical, mechanical

Vermont, University of: Civil, electrical, mechanical

Villanova College: Civil, electrical, mechanical

Virginia Military Institute: Civil, electrical

Virginia Polytechnic Institute: Ceramic, chemical, civil, electrical, industrial, mechanical

Virginia, University of: Chemical, civil, electrical, mechanical

Washington, State College of: Architectural, civil, electrical, mechanical (basic option), metallurgical, mining

Washington University: Architectural, civil, electrical, industrial (administrative), mechanical

Washington, University of: Aeronautical, ceramic, chemical, civil, electrical, mechanical, metallurgical, mining

Wayne University: Civil, electrical, mechanical

Webb Institute of Naval Architecture: Naval architecture and marine engineering

West Virginia University: Civil, electrical, mechanical, mining

Wisconsin, University of: Chemical, civil, electrical, mechanical, metallurgical, mining

Worcester, Polytechnic Institute: Chemical, civil, electrical, mechanical

Wyoming, University of: Civil, electrical, mechanical

Yale University: Chemical, civil, electrical, mechanical, metallurgical, (metallurgy)

List of Accredited Curricula of Technical Institute Type

Academy of Aeronautics (LaGuardia Field, N. Y.): Aircraft design and construction (resident full-time programs and resident part-time evening programs), aircraft mechanics and maintenance (resident full-time programs and resident part-time evening programs)

Aeronautical Institute (Hawthorne, Calif.): Electrical engineering

Aeronautical University, The (Chicago, Ill.): Aeronautical engineering drafting

Bliss Electrical School (Washington, D. C.): Fundamentals of industrial electrical engineering

Capitol Radio Engineering Institute (Washington, D. C.): Residence course in practical radio engineering, correspondence course in practical radio engineering

Franklin Technical Institute (Boston, Mass.): Industrial electricity

Wentworth Institute (Boston, Mass.): Machine construction and tool design, steam and Diesel engineering, architectural construction, electrical construction

United Engineering Trustees Elects New Officers

J. Schuyler Casey, president of the M. H. Treadwell Company, Inc., New York, N. Y., was elected president of the United Engineering Trustees, Inc., at its annual meeting, October 23, 1947, in the Engineering Societies Building, 29 West 39th Street. Mr. Casey (American Society of Mechanical Engineers) is also president of the Treadwell Construction Company, Midland, Pa., and chairman of the board of directors of the Treadwell Engineering Company, Easton, Pa. He succeeds J. P. H. Perry, vice-president of the Turner Construction Company, who served as president of United Engineering Trustees from 1945 to 1947.

Other officers elected were General William H. Harrison (F '31), a past president of AIEE, vice-president and chief engineer of the American Telephone and Telegraph Company, New York, N. Y., and director of procurement and distribution service, Office of Chief Signal Officer, Washington, D. C. (re-elected) as vice-president; Edward C. Meagher (American Institute of Mining and Metallurgical Engineers), assistant to the president, Texas Gulf Sulphur Company, New York, N. Y., as vice-president; Kurt W. Jappe (ASME) retired director of purchases, Hercules Powder Company, Wilmington, Del., and treasurer of ASME as treasurer; and James L. Head (AIME) department of mines, Chile Exploration Company, New York, N. Y., as assistant treasurer. John H. R. Arms (AIME, ASME) was re-elected as secretary.

Irving Huie (American Society of Civil Engineers) president of the Board of Water Supply, New York, N. Y., will head the real estate committee which includes William N. Carey, Secretary of ASCE; Everett S. Lee (AIEE, F '30) engineer-in-charge, general engineering laboratories of the General Electric Company, Schenectady, N. Y.; J. L. Head; K. W. Jappe; and J. S. Casey.

George L. Knight (ASME) retired vice-president of the Brooklyn Edison Company, will serve as chairman of the finance committee. Other members will be I. Huie, E. C. Meagher, K. W. Jappe, General Harrison, and J. S. Casey.

United Engineering Trustees is a corporation set up jointly by the four national engineering founder societies, the AIEE, AIME, ASCE and ASME.

The corporation promotes the advancement of the engineering arts and sciences in all their branches, through two departments, the Engineering Foundation and the Engineering Societies Library. The corporation is the titular owner of the Engineering Societies Building and of the trust funds of the library, the foundation, the John Fritz Medal board of award, and the Daniel Guggenheim Medal board of award.

HONORS

Lincoln Foundation Announces Awards

The trustees of the James F. Lincoln Arc Welding Foundation have announced the awards in its $200,000 "Design-For-Progress" program. The 467 awards range from $100 for honorable mention to $13,200 for the main award.

The first main award of $13,200 was divided among Paul F. Hackethal, chief engineer, Clarence C. Mast, shop superintendent, and Douglas W. Hamilton, welding foreman, all of the Koppers Company, Aeromatic propeller department, Baltimore, Md., for their coauthorship of a paper entered in the aircraft classification. Their paper described how welded design of a variable pitch propeller hub for light airplanes overcame the problems presented by low cost manufacture and strength requirements to withstand repeated loads of thrust torque, centrifugal pull, and gyroscopic action.

The propeller has brought new safety, economy, and speed to light private airplanes.

The second main award of $10,700 was awarded to Kiser E. Dumbauld, design engineer, of the Bureau of Bridges of the Ohio State Highway Department, for his paper in the structural building and bridges classification. His subject was the redesign to welded construction of three of Ohio's bridges.

The third main award of $8,200 went to G. J. Storatz, engineer-in-charge, the Heil Company, Milwaukee, Wis. His paper, entered in the industry machinery classification, described the redesign to welded construction of the company's Trailbuilder.

The many papers entered in the 15 different scientific and engineering classifications of the program were submitted from every section of the United States. They covered every field of design in manufacturing, research, and maintenance, through electric arc welding. Participants included scientists, engineers, production and supervisory personnel, maintenance and methods engineers from both private and large industrial operations.

The Lincoln Foundation was created in 1936. Its purpose, as stated in the deed of trust, "is to encourage and stimulate scientific interest in, and scientific study, research and education in respect of, the development of arc welding."

The 1946–47 award program is the third in a series of similar programs and is only one of the educational activities of the foundation. It conducts an annual undergraduate award and scholarship program in engineering schools. It also has provided funds to 250 engineering schools in the United States and other countries for the purchase of scientific books on welded design and applications. These libraries are maintained with contributions of the latest material on this subject as it is published. The foundation publishes a number of books. One now in the course of publication is called "Welding Helps For Farmers," and several textbooks containing the latest information on modern machine and structural design are in progress.

As a result of the present program, the foundation expects to publish a number of additional books. Of these, the chief one will be entitled "Design for Welding" and will be available early in 1948.

Building Named for Whitehead. A science building to be known as Whitehead Hall, named in honor of Doctor John Boswell Whitehead (F '12) professor emeritus of electrical engineering at Johns Hopkins University, Baltimore, Md. (*page 1254*), is being constructed on the Homewood campus of the institution. The 2-story-and-basement building will be the first structure at the university to be named for a living person. It will be located just north of the university's power plant. The building, expected to be completed early in the summer of 1948, will be in the red-brick Georgian style of the other university buildings, and each floor will be 65 by 106 feet. It will be used principally by the school of engineering and the other scientific departments.

INDUSTRY

Demand Grows for Electric Power

The growth in demand for electric service since V-J day has exceeded the most optimistic estimates, and kilowatt-hour production has been at record breaking levels, exceeding the peak wartime rate, according to an article in the September issue of *Business Comment*, a publication of The Northern Trust Company.

The electric utility industry added 2.1 million customers to its lines in 1946—more than in any previous year. Of this total, 1.8 million represented residential and rural customers while the balance was accounted for by commercial and industrial accounts. More than 90 per cent of all dwellings in the United States now have electricity, including 57 per cent of the nation's six million farms.

The potential market for new and old electric appliances is still vast. It is estimated that as of January 1, 1947, only 13 per cent of the wired homes in the United States had electric ranges, 7 per cent ironers, and only 5 per cent had electric water heaters. One-half of the homes had vacuum cleaners and 69 per cent had electric refrigerators. In addition, the more widespread availability of electricity to the American farm in recent years indicates a much higher level of consumption of electric energy by this group in the operation of both household appliances and farm machinery.

The war hastened the development of new industrial uses for electric power, many of which will be adopted permanently on an increasingly wider scale. Resistance welding, electroplating of metals, electric induction heating, and the X-ray inspection of products are but a few examples which should stimulate the growth of the industrial load. The refining or alloying of certain metals requires large amounts of power, and the production of these metals is far above prewar production. It also is believed that much of the greater than average growth in electric power sales in the South and Far West as a result of the industrial development in these regions during the war will be retained. It is of the greatest significance that even before the war the horsepower per industrial worker was almost twice as large in the United States as in Great Britain and Germany.

While electric power production has increased 75 per cent since 1939, generating capacity has expanded only 29 per cent, and the margin of reserve capacity has declined from 35 per cent to 12 per cent. With the present demand for electricity at peak levels and the margin of reserve capacity unusually narrow, some companies in certain localities have expressed concern regarding their ability to meet the demands of their customers at peak load periods during the day.

The pooling of facilities by interconnections between systems and the utilization of capacity at its maximum may alleviate such brief shortages. Meanwhile, to meet the large increase in demand, the industry has embarked upon a large scale expansion program. The Edison Electric Institute has estimated that orders have been placed by privately owned companies for approximately 12.2 million additional kilowatts of generating capacity to be installed in the next three to four years.

Railroad X-Ray Laboratory. The Pennsylvania Railroad has instituted a new X-ray laboratory embodying the most modern techniques for examining steel, aluminum, brass, and other metals used in rails, locomotives, cars, and other equipment to assure increased safety of railroad operation. The new X-ray plant has been opened at Altoona, Pa., as an addition to the Pennsylvania Railroad test department. A 250,000-volt mobile X-ray machine mounted on automobile wheels has been secured in order to use this new technique. The machine is capable of examining the internal structure of metals as much as three inches thick. Further plans call for the installation of a permanently mounted X-ray machine of 1,000,000-volt capacity in the laboratory buildings.

RCA Institutes' New President. Election of Major General George L. Van Deusen as president and a director of RCA Institutes, Inc., has been announced by David Sarnoff, president and chairman of the board of Radio Corporation of America. General Van Deusen commanded the Eastern Signal Corps Training Center during World War II. He succeeds Major General Harry C. Ingles, who served as head of the Institutes until his recent election as president of RCA Communications, Inc.

LETTER TO THE EDITOR

Motional Mass of the Electron

To the Editor:

I read with much interest C. A. Boddie's article on the motional mass of the electron (*EE, Jan '47, pp 45–60*) and I wish to express my great satisfaction with the manner in which the author has undertaken to clarify one of the essential points which should be understood as a basis for all scientific development.

Without doubt, the article has not failed

to provoke a certain uneasiness among the advocates of relativity. John F. Scully probably is attempting to show the falseness of the reasoning (*EE, Mar '47, pp 320–1*) in stating the Einstein syllogism that the value of the field given by the formula $E_s = \frac{E_0}{\sqrt{1-\beta^2}}$ cannot be applied to an electron moving through a field having a system of fixed co-ordinates. Unfortunately, the argument, as it is valid only in the logic of relativity, cannot be applied in reasoning and calculations based on classical concepts and methods.

It commonly is said in Greece, "You have spoken in Greek and he has answered in Chinese."

D. P. LOUKIDIS

(Electrical engineer, P. and D. Loukidis, Ingenieurs A. I. Lg., Athens, Greece)

NEW BOOKS • • •

"Principles of Electrical Engineering." According to the preface, the aim of this book is to present a comprehensive account of the basic principles of electrical engineering. The author has succeeded in doing this rather well. In 16 chapters a very wide range of subjects is covered—from fundamental units to propagation of electromagnetic waves in space. In general the approach is along the line of physics which is to be expected since the author is dealing with basic principles. The treatment of the subject is thorough and definitely not on an elementary level.

Among the subjects covered are units, structure of the atom, conductors, insulators, resistance, electrostatics, capacitance, networks, thermo-electricity, piezo-electricity, magnetism, magnetic materials and testing, electromagnetism, alternating currents, oscillating systems, graphical methods of solving electrical problems, non-sinusoidal waves, harmonic analysis, skin effect, transmission lines, and propagation of electromagnetic waves through space. The appendixes include tables of hyperbolic functions, circular functions, logarithms, values of e^{-x}, and data on skin effect. A group of 203 examples appears at the end of the book.

Several features of the book will bear criticism. For one thing the use of German script letters to denote vector quantities rather than the conventional bold face type certainly does not add clarity. The use of "hertz" for cycles per second is an unusual and undesirable departure from familiar notation. None of the diagrams have captions other than identifying figure numbers. A good proportion of the problems at the end of the book are illustrative and not numerical. Finally, in a book that covers such a wide scope, it would seem desirable to identify the various sections in each chapter by numbers, such as 1-1, 1-2, 1-3, for sections of chapter one, for quick and easy reference.

In general the book is very well done and will be useful addition to the power as well as communications engineer's library. By T. F. Wall. Remson Press Division of the Chemical Publishing Company, Inc., Brooklyn, N. Y., 1947, 563 pages, cloth-bound, 8½ by 5½ inches, $8.50.

"Electrical Engineering Problems and Their Solutions." This is a collection of worked-out solutions to the problems that appear at the end of the companion volume, "Principles of Electrical Engineering," by the same author.

In many instances, answers to questions like "give an account of the electron theory of the action of a crystal detector" cannot be found in the companion volume. However, this is intentional on the author's part. He intended some of the problems to be answered by reference to the literature. Thus the answers to questions of this type form a supplement to the companion volume.

In this regard it is gratifying to note several questions on electronic circuits—a subject which is not treated in the companion volume at all. By T. F. Wall. Remson Press Division of the Chemical Publishing Company, Inc., Brooklyn, N. Y., 1947, 312 pages, cloth-bound, 8½ by 5½ inches, $5.

"Television Receiving Equipment (second edition)." A valuable reference for British television standards and methods, the book also may serve as text for elementary theory and calculations, as well as a history of development in the television field. Although there have been no fundamental changes in British commercial television practice since the end of World War II, the prewar first edition has been revised to include material on technique improvements. By W. T. Cocking. Jliffe and Sons, Ltd., London, England, 1947, 380 pages, illustrated, cloth-bound, 4¼ by 7 inches.

OPERATED jointly by the AIEE and the other Founder Societies, the Engineering Societies Library, 29 West 39th Street, New York 18, N. Y., offers a wide variety of services to members all over the world. Information about these services may be obtained on inquiry to the director.

CONTROL CHARTS, AN INTRODUCTION TO STATISTICAL QUALITY CONTROL. By E. S. Smith. McGraw-Hill Book Company, New York, N. Y., and London, England, 1947. 161 pages, diagrams, charts, tables, 9¼ by 6 inches, cloth, $3. Providing a simple nonmathematical introduction to the methods and charts of statistical quality control, this volume presents the material with emphasis on practical applications. The first chapter stresses the importance of statistical methods. Chapter 2 deals with frequency curves and their use in analyzing statistical data. The charts are to be found in chapters 3 and 4, while chapter 5 is devoted to formulas used in previous discussions. Features of this book are a new method of determining satisfactory location of control limits with respect to specification limits and a labor-saving table for computing control limits for a chart of fraction derivatives.

ELECTRONIC ENGINEERING PRINCIPLES. By J. D. Ryder, Prentice-Hall, Inc., New York, N. Y., 1947. 397 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $6.65. With the object of supplying the physical fundamentals needed for an understanding of electron tubes, this volume covers theories of conduction, simple atomic structure, and generalized circuit analysis with linear and non-linear circuit elements. A basic knowledge of a-c network theory and mathematics through simple differential equations is assumed. The physics involved in emission, space charge, and gaseous conduction phenomena is explained. Theory and applications are grouped closely, and applications are chosen mainly from the industrial field. An appendix contains selected vacuum tube characteristic curves and data. References are given at the end of each chapter.

MATHEMATICS FOR RADIO ENGINEERS. By L. Mautner. Pitman Publishing Corporation, New York, N. Y., and London, England, 1947. 327 pages, diagrams, charts, tables, 9¼ by 6 inches, cloth, $5. Designed for the practicing technician as well as for engineering students, this book covers in considerable detail the mathematics required to solve everyday design problems in radio, electronics, radar, and associated fields. Beginning with a review of simple algebra and a discussion of logarithms, the book continues through the calculus, ending with differential equations and Fourier series. Illustrative engineering applications are provided in addition to the selected group of problems accompanying each chapter.

PHILIPS RESISTANCE WELDING HANDBOOK. Philips Industrial (Philips Lamps Ltd.), Century House, Shaftesbury Avenue, London, W. C. 2, England, 1947. 210 pages, illustrations, diagrams, charts, tables, 9 by 5½ inches, cloth, 10s/6d. Dealing with the integration of resistance welding into the general process of production, this manual is of interest to those who wish to know practical applications. It is not intended to be a technical manual for the design of resistance welding machines. Welding equipment and principles, metallurgy of resistance welding, auxiliary equipment, and planning for resistance welding are the main topics covered. The reader should be familiar with the principles of electricity, magnetism, and general engineering.

PAMPHLETS • • •

Special Ceramic Materials and Their Industrial Application. This booklet covers improved ceramic dielectric materials for electrical or electronic purposes; improved stoneware, as used for chemical engineering purposes, and chemical porcelain for industrial purposes. General Ceramics and Steatite Corporation, Keasbey, N. J.

A New Era in Liquid and Gas Flow Measurement. A general discussion of the Flowrator (formerly called Rotameter) for flow rate measurement. Basic principles, flexibility, accuracy, linear flow characteristics, flow range, and immunity of calibration to variations in fluid viscosity are covered. Available without charge from Fischer and Porter Company, Department 8M-F, Hatboro, Pa.

"Control Humidity If You Want Comfort from Air Conditioning" is an eight page booklet published by the Surface Combustion Corporation, Toledo 1, Ohio.

United States Patents on Powder Metallurgy. A list of patents relating to powder metallurgy, classified in related groups with a short abstract of each invention, intended to simplify the study of patent literature on this subject. Superintendent of Documents, United States Government Printing Office, Washington 25, D. C. 30 cents.

AIEE Officers and Committees for 1947-48

New Plan of AIEE Committee Organization

REVISED FROM
ELECTRICAL ENGINEERING
OCTOBER 1947
ISSUED NOVEMBER 1947

New AIEE Committee Organization

THE ADMINISTRATION of committee activities of the Institute gradually is evolving toward greater unification of groups which have related interests. The board of directors, at its April meeting in Worcester, Mass. (*EE, June '47, pp 597–8*), set in motion a series of changes intended to revitalize the entire committee structure. Immediately after the meeting, Blake D. Hull, then the presidential nominee, started the formation of the new committee organization in order to enter upon the new year with a full personnel.

Prior to the Worcester meeting, the technical committees had been operating informally in a group or divisional organization as suggested by the directors at their Asheville, N. C., meeting in 1946 (*EE, June '46, pp 269–70*). At Worcester, the Asheville resolution was amended to read as follows:

Resolved that it is the sense of the board of directors that the development of the technical committee activities of the Institute should be guided by the following principles:

1. That such additional technical committees should be organized as may be needed to cover the important items of electrical technology.

2. That these technical committees should be grouped in appropriate divisions or groups with a co-ordinating committee for each group fairly compact in numbers and consisting essentially of a group chairman and the chairmen of the technical committees comprising the group.

3. That each year the group co-ordinating committees make informal recommendations to the presidential nominee through the secretary on the membership and organization of the whole technical committee structure, including at least two alternates for every co-ordinating committee chairmanship.

4. That in such recommendations a reasonable turnover of the committee personnel be the intention. Further, that it is the intent of this board that the responsible committees should proceed with such changes as they may determine to be necessary and proper to effectuate these principles unless the proposed changes are at variance with either the constitution or the bylaws, in which event they shall be referred back to the board for further consideration.

The directors voted to establish initially four co-ordinating committees for the technical committees, and also to establish several new technical committees in addition to those previously established at their January and October meetings. The new technical committee setup (including several changes adopted by the board of directors on August 11, 1947) follows:

Power Co-ordinating Committee

Carrier current committee
Electronic power converter committee
Insulated conductor committee
Power generation committee
Protective devices committee
Relay committee
Rotating machinery committee
Substation committee
Switchgear committee
System engineering committee
Transformer committee
Transmission and distribution committee

Industry Co-ordinating Committee

Chemical, electrochemical, and electrothermal committee
Electric heating committee
Electric welding committee
General industry applications committee
Industrial control committee
Industrial power systems committee
Mining and metal industry committee

Communication and Science Co-ordinating Committee

Basic sciences committee
Communication, committee
Electronics committee
Instruments and measurements committee
Nucleonics committee
Therapeutics committee

General Applications Co-ordinating Committee

Air transportation committee
Domestic and commercial applications committee
Land transportation committee
Marine transportation committee
Production and application of light committee

In general the name of the committee describes its functions. Other duties are defined in sections 65, 85, 86, and 108 of the bylaws of the Institute.

No changes in the constitution and no major changes in the bylaws were required to accomplish the reorganization. As before, all committees are directly responsible to the board of directors; as before, and as provided in the bylaws "in respect of matters affecting standardization or nomenclature, the several committees named shall submit to the Standards committee such recommendations as they may deem proper;" as before, "in respect of papers and discussions, these committees shall report to the technical program committee to correlate the work of their committees in such a manner as effectively will provide adequate opportunity for discussion of each of the various topics included within the scope of Institute activity, and to arrange the presentation and discussion of such papers as may receive its approval." The chairman of each technical committee will continue to be a member of the technical program committee which also includes the chairmen of technical co-ordinating committees, the committees on planning and co-ordination, safety, Standards, educa-

tion, and research. The technical committees themselves will do the work of co-ordinating and correlating their activities within their own groups.

One year of experience with this organization scheme leads to the belief that a combination of flexibility and efficiency can be achieved which will give complete and current coverage to all areas of the large field of technical activity of the Institute. Subjects, papers, and duties can be transferred among committees and among groups or divisions. Co-operation, under the co-ordinating committees, comes about by common consultation and common consent.

A similar grouping of activities will be tried among the general committees. At Worcester the directors, in addition to endorsing the principle of divisional organization, voted to establish two new co-ordinating committees, one on professional and one on administrative activities, for the coming year. Also established by the directors at their Worcester meeting, is a new general committee, the management committee, which is included in the professional activities group. The new groups follow:

Administration Group Co-ordinating Committee

Board of examiners
Constitution and bylaws committee
Headquarters committee
Institute publicity committee
Members-for-life fund committee
Membership committee
Transfers committee

Professional Activities Co-ordinating Committee

Award of Institute prizes committee
Charles LeGeyt Fortescue fellowship committee
Code of principles of professional conduct committee
Edison Medal committee
Education committee
Lamme Medal committee
Management committee
Registration of engineers committee
Student Branches committee

Not included in any divisional group are the remaining general committees which will continue to operate as at present. These are

Finance committee
Planning and co-ordination committee
Publication committee
Research committee
Safety committee
Sections committee
Standards committee
Technical program committee

The committee on planning and co-ordination, however, will include within its membership the chairmen of the six co-ordinating committees. The divisional structure of the general committees will be worked out in more complete detail as the next administrative year progresses.

The following sections list the various technical committees. The co-ordinating committee is given first, then the name and scope of the various committees represented in that particular co-ordinating committee.

Personnel are listed on pages 9-12.

Power Group

POWER CO-ORDINATING COMMITTEE

M. J. Steinberg, *chairman*, Consolidated Edision Company of New York, Inc., 4 Irving Place, New York, N. Y.
H. W. Collins, *vice-chairman*
R. T. Henry
A. J. Krupy
Frank Thornton, Jr.
C. C. Wilson, *secretary*
Ex-officio: chairmen of technical committees in the power group

CARRIER CURRENT COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the design, construction, and operation of equipment and circuits for the application of carrier currents in the generation, transmission, and distribution of electric power. Included in the scope of this committee shall be treatment of the following:

Carrier current equipment and circuits for
  Relaying
  Control (supervisory, load, frequency, and so forth)
  Metering
  Communication as applied to power system use
also:
Line traps
Coupling capacitors

ELECTRONIC POWER CONVERTER COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the design, construction, and operation of equipment and circuits for the electronic conversion of electric energy into other phases of electric energy in the generation, transmission, distribution, and utilization of electric power. This scope shall not include hot-cathode-type converters which have been assigned to the hot cathode electronic power converters subcommittee of the electronics committee. There shall be included in this scope treatment of the following:

Electronic converters for motor control (joint with industrial control committee)
Electronic power rectifiers and inverters
Electronic frequency changers

Matters relating to electronic converters specifically designed for applications covered by certain other technical committees such as communication, transportation, industrial power systems, and electrochemical applications may be treated jointly with that committee if emphasis is on general principles; or exclusively by the application committee if emphasis is on the particular requirements of the application.

INSULATED CONDUCTOR COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the design, construction, and operation of insulated conductors and the accessories thereto used in the generation, transmission, distribution, and utilization of electric power. Included in this scope shall be treatment of the following:

Cable supply systems (including solid, oil-filled, and gas-filled cables)
Insulated wire and cable
Accessories (including potheads, wiring ducts, and conduit, not including insulated bus runs as in metal-clad switchgear)
Structures (joint with transmission and distribution committee)
Cable characteristics
Insulations
Sheaths and coverings
Utilization wiring systems

Special purpose cables
Tests and measurements

Matters relating to insulated conductors specifically designed for applications covered by certain other technical committees such as communication, transportation, and electric heating may be treated jointly with that committee if emphasis is on general principles; or exclusively by the application committee if emphasis is on the particular requirements of the application.

POWER GENERATION COMMITTEE

Scope—Treatment of all matters relating to the design, construction, and operation of electric power generating stations, including auxiliary equipment incidental thereto (where such equipment is not otherwise specifically assigned to other technical committees).

Treatment of all matters pertaining to the design, construction, and operation of steam boiler plants, dams, reservoirs, nuclear piles, and other primary sources of energy to prime movers; also the prime movers themselves used in the generation of electric energy.

Treatment of all matters relating to the economics of generation and supply of electric power within individual generating stations.

Included in this scope shall be treatment of the following:

Prime movers (hydro, steam, oil, gas, nuclear, wind power)
Speed governors for prime movers
Station load and frequency control (joint with system engineering committee)
Control systems (joint with substation committee)
Excitation systems and voltage regulators
Station design (generating plant)
Auxiliaries and accessories
Production costs—design and operating economics (separate station)
Co-ordination of prime mover and electric machine design
Bus design (joint with switchgear and substation committees)

PROTECTIVE DEVICES COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the design, construction, and operation of devices and equipment to limit or prevent damage to electric power generation, transmission, or distribution systems, or equipment; such damage arising from excessive current, voltage, or from lightning. Included in this scope shall be treatment of the following:

Capacitors (where used as protective devices)
Lightning protective devices (such as arrestors, protector tubes, air gaps, and expulsion gaps)
Fault limiting devices (including neutral grounding devices)
Lightning investigations (joint with transmission and distribution committee)
Reactors and grounding transformers (joint with transformer committee)

Matters relating to protective devices specifically designed for applications covered by certain other technical committees such as industrial control, industrial distribution systems, or communication, may be treated jointly with that committee if emphasis is on general principles; or exclusively by the application committee if emphasis is on the particular requirements of the application.

RELAY COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the design, construction, and operation of protective relays including all matters necessary to the functioning of such relays employed in the generation, transmission, and distribution of electric energy. Included in this scope shall be treatment of the following:

Relays and automatic devices (fault and load discriminating)
Relay protective schemes, including relay co-ordination
Potential devices
Bushing and instrument transformers (joint with instruments and measurements committee)

Matters relating to relays specifically designed for applications covered by certain other technical committees such as industrial control, communication, and transportation may be treated jointly with that committee if emphasis is on general principles; or exclusively by the application committee if emphasis is on the particular requirements of the application.

ROTATING MACHINERY COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the requirements, design, construction, and operation of rotating machinery for the generation of electric energy or its conversion into other forms of energy. There shall be included in this scope treatment of the following:

Synchronous machines
Induction machines
D-c machines
Single phase and fractional horsepower machines
Motor generator sets
Rotating frequency changers
Rotating phase balancers
Synchronous converters
Insulation and dielectric problems related to rotating machinery

Matters relating to rotating machinery specifically designed for applications covered by certain other technical committees such as electric welding, transportation, or communication may be treated jointly with that application committee if the emphasis is on general principles; or exclusively by the application committee if the emphasis is on the particular requirements of the application.

SUBSTATION COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the electrical and structural design, construction, installation, operation, and control of automatic, semiautomatic, and nonautomatic substations, including switching and transformer stations.

Included in the scope of this committee shall be treatment of the following:

Automatic, semiautomatic, and nonautomatic substations
Switching stations
Fundamental single line wiring diagrams
Bus design (joint with switchgear and power generation committees)
Automatic and supervisory control systems (joint with power generation committee)
Supervisory control devices
Structural arrangements for substations
Telemetering (joint with instruments and measurements committee)
Insulation co-ordination (joint with transmission and distribution committee)

SWITCHGEAR COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the design, construction, and operation of devices or assembled gear to establish (make), interrupt, or change connections in an electric circuit under normal or abnormal conditions. Included in this scope shall be treatment of the following:

Power circuit breakers
Large air circuit breakers
Low-voltage air circuit breakers
Switchgear assemblies
Switches
Insulating fluids (joint with transformer committee)
Bus design (joint with power generation and substation committees)
Insulation, insulators, and hardware for switchgear
Automatic reclosers
High-voltage fuses and cutouts (above 600 volts)

Matters relating to switchgear or switchgear devices specifically designed for applications covered by certain other technical committees such as industrial control, communication, electronics, and transportation may be treated jointly with that committee if emphasis is on general principles; or exclusively by the application committee if emphasis is on the particular requirements of the application.

SYSTEM ENGINEERING COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the requirements, planning, co-ordination, operation, and eco-

nomics of interconnected electric generating, transmission, and distribution systems. Included in this scope shall be treatment of the following:

Interconnected system planning
Frequency and load control (joint with power generation committee)
Load dispatching
Economics of system and unit operation
Engineering of system expansion
Interconnection contracts

TRANSFORMER COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the design, construction, and operation of transformers, reactors, and other similar equipment. Included within this scope shall be treatment of the following:

Transmission and distribution transformers
Voltage and load regulators (step and induction regulators)
Reactors and grounding transformers (joint with protective devices committee)
Specialty transformers and regulating transformers
Railway service transformers
Test transformers
Constant current transformers
Insulating fluids (joint with switchgear committee)
Insulation and dielectric problems relating to transformers
Insulators and hardware for transformers

Matters relating to transformers and regulators specifically designed for applications covered by certain other technical committees such as relays, electronics, protective devices, communication, may be treated jointly with that committee if emphasis is on general principles; or exclusively by the application committee if emphasis is on the particular requirements of the application.

TRANSMISSION AND DISTRIBUTION COMMITTEE

Scope—Treatment of all matters in which the dominant factors are considerations of economical and technical design, theoretical and experimental performance, installation, and service operation of that part of electric power systems which serve to transmit electric energy between the generating source or substation and the service.

Treatment of all matters involving substations themselves including switching and transforming stations are not within the scope of this committee, except in the broad aspects of the application of a substation as a whole.

Treatment of matters involving industrial distribution systems shall not be included within this scope unless such systems are interconnected with an electric power utility, in which case the action shall be joint with the committee on industrial power systems.

Included in this scope shall be treatment of the following:

Overhead and underground transmission and distribution systems
Overhead conductors
Fault current studies
System stability
Lightning investigations (joint with protective device committee)
Structural co-ordination
Insulation co-ordination (joint with substation committee)
Inductive co-ordination
Corona
Towers, pole, insulators, and hardware
Capacitors (except those used for protective devices)

Industry Group

INDUSTRY CO-ORDINATING COMMITTEE

Herbert Speight, *chairman*, Westinghouse Electric Corporation, 40 Wall Street, New York, N. Y.
J. J. Orr, *vice-chairman*
J. Elmer Housley
C. C. Wilson, *secretary*
Ex-officio: chairmen of technical committees in the industry group

CHEMICAL, ELECTROCHEMICAL, AND ELECTROTHERMAL COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the generation of electricity through chemical processes, and the application of electricity to chemical or metallurgical operations (exclusive of electric welding and the phenomena of the arc insofar as it is concerned with the deposition of metal in welding, which is a function of the electric welding committee, and exclusive of magnetics, which is a function of the basic sciences committee), including the relations, installation, and operation of the devices necessary thereto, and the requirements of specialized devices, materials, or construction peculiar thereto.

ELECTRIC HEATING COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the requirements, selection, installation, and operation of machines, devices, and equipment relating to electric heating of all kinds, including dielectric and induction, radiation, resistance, and high temperature furnaces. Design and theory of devices shall be handled by consultation with electronics or other committees as required.

ELECTRIC WELDING COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the requirements, design, construction, selection, installation, and operation of machinery and devices relating to electric welding, including studies of the electromagnetic phenomena of the arc insofar as it is concerned with the deposition of metal in welding. Such subjects as electric welding methods and the electric machinery and control equipment specially designed for welding are properly within the scope of this committee.

GENERAL INDUSTRY APPLICATIONS COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the requirements, selection, installation, and operation of machinery and devices relating to machine tools and to the processing and/or fabrication (assembly) of nonmetallic materials. Such materials include textiles, rubber, paper, plastics.

The problems relating to assembly line processes of all materials are considered within the scope of this committee.

INDUSTRIAL CONTROL COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the design, construction, and performance of industrial control, and the way in which it serves to govern in some predetermined manner the electric power delivered to the apparatus to which it is connected.

INDUSTRIAL POWER SYSTEMS COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the requirements, selection, co-ordination, installation, and operation of machines, devices, and equipment necessary for generating and transmitting electric power within an industrial plant for use solely by that plant. (Actual design of devices and equipment not included.) Design of distribution systems within the industrial plant are a part of the scope of this committee.

When such industrial systems are interconnected with public systems, the action shall be joint with the committee on power generation or on transmission and distribution.

MINING AND METAL INDUSTRY COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the requirements, selection, installation, and operation of

machinery and devices relating to the processing of metal and those relating to mining of any kind.
Matters pertaining to blast furnaces, metal rolling, and metal drawing are properly within the scope of this committee.

Communication and Science Group

COMMUNICATION AND SCIENCE CO-ORDINATING COMMITTEE

W. R. G. Baker, *chairman*, General Electric Company, Electronics Department, Thompson Road, Syracuse, N. Y.
Truman S. Gray, *vice-chairman*
O. E. Buckley
F. A. Cowan
Ex-officio: chairmen of technical committees in the communication and science group

BASIC SCIENCES COMMITTEE

Scope—Treatment of all matters in which the dominant factor is electrophysics, and which are of such novel character as to be unapplied in any apparatus or field of application within the scopes of the other technical committees, or which are of such generality as to be significant within the scopes of several technical committees. Such subjects as general circuit theory, electrostatics, mathematical treatises, magnetics, general electrical units, and nomenclature are properly within the scope of this committee.

COMMUNICATION COMMITTEE

Scope—Treatment of all matters in which the dominant factor is the electrical transmission of intelligence (exclusive of supervisory control, which is a function of the substations committee, and railway signaling, which is a function of the land transportation committee), including methods, materials, devices, and construction to accomplish the result. Such subjects as telegraphy; telephony; program transmission; telephotography; television; police alarm, fire alarm, burglar alarm and traffic control systems; messenger calls; and time service are within the scope of this committee. Where communication lines are utilized in other fields, for example, the communication requirements of electric power systems and railways, or where problems of inductive coordination arise, treatment shall be joint with the respective technical committees concerned.

ELECTRONICS COMMITTEE

Scope—Treatment of all matters in which the dominant factor is electronics, particularly those dealing with the design, characteristics, or behavior of devices of an electronic nature, or of the circuits associated with them. The treatment of complete equipments or systems may be considered within the scope of this committee if they depend predominantly on electronic devices for their operation. If the field of application of such equipments or systems falls also within the scope of other technical committees, action with those committees may be joint.

INSTRUMENTS AND MEASUREMENTS COMMITTEE

Scope—Treatment of all matters in which the dominant factor is the measurement of electrical quantities, both absolute and relative, and the measurement of other quantities by electrical methods, including the devices necessary thereto. Where novel instruments and novel methods of electrical measurement are in papers, even though measurement is not the prime objective, then action shall be joint with the respective technical committee concerned.
Telemetering is assigned primarily to the committee on instruments and measurements and handled by a joint subcommittee comprised of members of both the committees on substations and instruments and measurements. Telemetering problems in connection with automatic stations will be assigned by the chairman of the committee on instruments and measurements to members of the subcommittee who are also members of the committee on substations. Telemetering problems of a more general nature will be assigned by him to members of both main committees, and where the problem is simply measurements it will be assigned only to members of the committee on instruments and measurements (as per joint agreement between the committees on automatic stations and instruments and measurements, January 29, 1935).

NUCLEONICS COMMITTEE

Scope—Treatment of all matters in which the dominant factor is nucleonics, particularly that dealing with the design, characteristics, or behavior of devices of a nucleonic nature, or of the systems associated with them. The treatment of complete equipments or systems may be considered within the scope of this committee if they depend predominantly on nucleonic principle for their operation. If the field of application of such equipments or systems falls also within the scopes of other technical committees, action with those committees shall be joint.

THERAPEUTICS COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the application of electric power to sanitation equipment, such as air-cleaning and sterilizing devices, and to the promotion of health and the analysis and treatment of disease or defects of the human body, such as X-ray equipment, diathermic equipment, cardiographs, investigations not directly applying to the human body but relating to health, and electric devices suitable for such purposes; the study of harmful effects of electric currents and radiations of electric devices upon the human body and means for the prevention of such effects, and so forth, are properly within the scope of this committee.

Where certain devices are suitable for both therapeutic and industrial purposes, such as some X-ray equipment, or for therapeutic and other scientific investigations, or for sanitation and air-conditioning of domestic and commercial premises, action shall be joint with the industrial power applications committee, the basic sciences committee, or the domestic and commercial applications committee, respectively; also, when appropriate, with the safety committee.

General Applications Group

GENERAL APPLICATIONS CO-ORDINATING COMMITTEE

S. G. Hibben, *chairman*, Westinghouse Lamp Division, Bloomfield, N. J.
C. C. Whipple, *vice-chairman*
Elgin B. Robertson
Ex-officio: chairmen of technical committees in the general applications group

AIR TRANSPORTATION COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the design, installation, and performance of airplane equipment, including batteries, generating equipment, voltage regulators, instruments, wiring devices, motors, special controls, reverse current cutouts, bonding, shielding, filtering, inverters, dynamotors, lightning detection and protection, lighting (interior and exterior), system characteristics, weight-power relationships,

and heating devices. With respect to communication and navigation; ground lighting; electric testing equipment for measuring strain, vibration, noise, corrosion, and so forth; and electric welding of airplane structures; action should be in co-operation with the respective AIEE technical committees in these fields and similar committees of other organizations.

DOMESTIC AND COMMERCIAL APPLICATIONS COMMITTEE

Scope—Treatment of all matters in which the dominant technical factors are the interior supply and utilization of electric power in domestic premises, such as single or multiple dwellings, garages, and other accessory structures, and in institutional buildings such as hospitals, schools, libraries, and so forth. Such subjects as control, interior wiring, heat-operated and motor-operated appliances or equipment for use in domestic, commercial, or institutional premises, including elevators and escalators, are properly within this scope. Subjects relating to the production and application of light, as such, are within the scope of the production and application of light committee.

LAND TRANSPORTATION COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the requirements, design, selection, relation, and operation of electric apparatus and material for transportation (exclusive of air and marine transportation, which are functions of the air transportation and marine transportation committees) of passengers and freight and the economic questions incident thereto. Such subjects as the electrification of steam railways, street railways, pantograph trolleys and overhead catenaries, electric locomotives (oil-electric, gasoline-electric, or 3-power locomotives), multiple-unit cars, electric-traction motors, main and auxiliary control equipment, railway substations, mercury-arc rectifier applications, and railways signaling and automatic train control are within the scope of this committee.

MARINE TRANSPORTATION COMMITTEE

Scope—Treatment of all matters in which the dominant factors are the application, relation, and installation of electric machinery and materials of whatever nature on shipboard, and the requirements for specialized devices, materials, or constructions peculiar to such application.

PRODUCTION AND APPLICATION OF LIGHT COMMITTEE

Scope—Treatment of those matters in which the dominant factor is the application of electric energy through its conversion into light, including necessary materials, devices, and mechanisms, insofar as these matters are considered of interest and value to the members of the Institute. This committee functions as a liaison between the Institute and various organizations dealing with the production and utilization of light, such as the Illuminating Engineering Society, the Optical Society of America, and others. Its activities include translating the theoretical and technical accomplishments of those organizations into terms of the practical aspects of the production and application of light, thereby serving to inform Institute members of important progress in this field. Where problems of electrical supply service, voltage, or distribution are involved, action shall be joint with the transmission and distribution committee.

Officers and Committees for 1947-48

Officers

President

B. D. HULL — Dallas, Tex.
(Term expires July 31, 1948)

Junior Past Presidents

C. A. POWEL — East Pittsburgh, Pa.
(Term expires July 31, 1948)

J. ELMER HOUSLEY — Alcoa, Tenn.
(Term expires July 31, 1949)

Vice-Presidents

District		
1	E. W. DAVIS	Cambridge, Mass.
3	O. E. BUCKLEY	New York, N. Y.
5	T. G. LeCLAIR	Chicago, Ill.
7	R. F. DANNER	Oklahoma City, Okla.
9	C. F. TERRELL	Seattle, Wash.
	(Terms expire July 31, 1948)	
2	G. W. BOWER	Haddonfield, N. J.
4	J. H. BERRY	Norfolk, Va.
6	I. M. ELLESTAD	Omaha, Nebr.
8	D. I. CONE	San Francisco, Calif.
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Sections

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Akron	2	Aug. 12, '20	154	F. I. Ilse	C. R. Reid	The Hoover Company, North Canton, Ohio
Alabama	4	May 22, '29	135	E. W. Robinson	T. S. Birdsong	Elec. Engg. Dept., Alabama Power Co., Birmingham, Ala.
Arizona	8	Mar. 22, '41	97	C. A. Poppino	F. J. Groat	Bureau of Reclamation, 443 Security Bldg., Phoenix, Ariz.
Arkansas	7			J. H. Tole	H. W. Claybaugh	305 South Elm, Little Rock, Ark.
Arrowhead	5		34	A. C. Smythe	J. F. Johnson	Minnesota Power & Light Co., Duluth, Minn.
Beaumont	7	June 27, '45	73	C. A. Daniel	John W. Millington	Sun Oil Co., Beaumont, Texas
Boston	1	Feb. 13, '03	766	W. Irving Middleton	L. F. Cleveland	Northeastern University, 360 Huntington Ave., Boston 15, Mass.
Central Indiana	5	Jan. 12, '12	197	J. R. Pies	G. F. Switzer	Indianapolis Power and Light Co., 17 N. Meridian St., Indianapolis 6, Ind.
Chicago	5	1893	1,381	J. E. Hobson	F. D. Troxel	Sargent & Lundy, 140 S. Dearborn St., Chicago 3, Illinois
Cincinnati	2	June 30, '20	198	Howard E. Barnett	W. H. McNutt	Westinghouse Elec. Corp., 207 W. Third St., Cincinnati 2, Ohio
Cleveland	2	Sept. 27, '07	583	O. N. Jones	R. L. Oetting	General Elec. Co., Nela Park, Cleveland 12, Ohio
Columbus	2	Mar. 17, '22	116	Robert C. McMaster	Edward J. Ramaley	Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio
Connecticut	1	Apr. 16, '21	475	Chester D. Hewitt	Elmer G. Horton	Westinghouse Elec. Corp., P.O. Box 1817, New Haven 8, Conn.
Dayton	2	June 9, '43	273	W. A. Barden	L. H. Fox	2008 Rugby Road, Dayton 6, Ohio
Denver	6	May 18, '15	325	L. R. Patterson	Evan R. Jones	Mountain States Tel. & Tel. Co., Box 960, Denver 1, Colo.
East Tennessee	4	Sept. 2, '36	290	J. J. Hill	I. M. Barnes	Tenn. Valley Authority, Power Bldg., Chattanooga 2, Tenn.
Erie	2	Jan. 11, '18	110	M. W. Kitzmiller	F. T. Parker	2304 Bird Drive, Erie, Pa.
Florida	4	Jan. 28, '31	181	C. H. Summers	Robert M. Garth	5021 Sunderland Road, Jacksonville 5, Fla.
Fort Wayne	5	Aug. 14, '08	124	M. L. Schmidt	C. J. Herman	General Elec. Co., 1435 Broadway, Fort Wayne 2, Indiana
Georgia	4	Jan. 14, '04	193	Marion S. Johnson	James R. Raney	Georgia Power Co., 75 Marietta St., N.W., Atlanta, Ga.
Houston	7	Aug. 7, '28	227	H. Lee Miller	W. O. Ray	6647 Lindy Lane, Houston 12, Tex.

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Sections (continued)

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Illinois Valley	5	June 30, '45	95	G. H. Duff	R. P. Pfeiffer	2318 Missouri Ave., Peoria 4, Ill.
Iowa	5	June 29, '29	115	W. L. Cassell	John V. Gebuhr	1128 Oak Park Ave., Des Moines 13, Iowa
Ithaca	1	Oct. 15, '02	112	W. W. Perry	H. L. Livingood	N. Y. State Elec. & Gas Corp., 62 Henry St., Binghamton, N. Y.
Kansas City	7	Apr. 14, '16	221	T. L. Jones	P. A. Haas	Board of Public Utilities, 6th & Ann Ave., Kansas City 16, Kansas
Lehigh Valley	2	Apr. 16, '21	244	F. W. Smith	A. L. Price	173 S. Church St., Hazleton, Pa.
Los Angeles	8	May 19, '08	1,027	H. D. Strong	Eugene L. Bettannier	City Hall, Room 302, 100 North Garfield Ave., Pasadena 1, Calif.
Louisville	4	Oct. 15, '26	104	Harry Hadsel	M. G. Northrop	Speed Scientific School, Univ. of Louisville, Louisville 8, Ky.
Lynn	1	Aug. 22, '11	255	M. A. Princi	Richard G. Slauer	Sylvania Elec. Products Co., Inc., 126 Washington St., Salem, Mass.
Madison	5	Jan. 8, '09	67	Berhnard C. Lueders	Lawrence F. Kehoe	Dairyland Power Co-operative, Rivoli Bldg., LaCrosse, Wis.
Mansfield	2	Mar. 6, '39	66	H. E. Edwards	E. C. Ryan	425 Overlook Road, Mansfield, Ohio
Maryland	2	Dec. 16, '04	512	Edwin Hansson	F. H. Rogers	Meter & Installation Dept., Consolidated Gas & Elec. Lt. Pr. Co., Baltimore 3, Md.
Memphis	4	May 22, '30	139	Maury G. Sifford	James R. Morton	Memphis Light, Gas & Water Div., Box 388, Memphis 1, Tenn.
Mexico	7	June 29, '22	209	Manuel M. DeLascurain	George B. Doughman	Calle de la Palma 33, Apartado 2530 Mexico, D. F., Mexico
Michigan	5	Jan. 13, '11	652	A. W. Rauth	M. R. Horne	22187 W. Michigan Ave., Dearborn, Mich.
Milwaukee	5	Feb. 11, '10	553	L. C. Aicher	E. H. Fredrick	Allis-Chalmers Mfg. Co., Milwaukee 1, Wisconsin
Minnesota	5	Apr. 7, '02	212	John H. Merriman	Lincoln A. Rietow	Control Corporation, Minneapolis 14, Minnesota
Montana	9	June 24, '31	85	W. H. Blankmeyer	D. E. Kampschror	Westinghouse Elec. Corp., 52 East Broadway, Butte, Montana
Montreal	10	Apr. 16, '43	262	H. W. Haberl	N. L. Morgan	Northern Elec. Co. Ltd., 1261 Shearer St., Montreal, Que., Canada
Muscle Shoals	4	Feb. 18, '38	24	W. E. Lindemann	E. V. Raffalovich	208 Circular Drive, Florence, Ala.
Nebraska	6	Jan. 21, '25	72	R. L. Schacht	James Pros, Jr.	General Elec. Supply Corp., 914 N. 18th St., Omaha 2, Nebr.
New Mexico–West Texas	7	Mar. 7, '40	82	John A. Davis, Jr.	Lee R. Hammond, Jr.	2910 Grant Ave., El Paso, Texas
New Orleans	4	Dec. 8, '33	231	W. D. Stroud	E. I. Blanchard	Louisiana Power & Light Co., 433 Metairie Rd., New Orleans 20, Louisiana
New York	3	Dec. 10, '19	4,509	W. J. Barrett	D. W. Taylor	Public Service Elec. & Gas Co., 80 Park Place, Newark 1, N. J.
Niagara Frontier	1	Feb. 10, '25	268	H. G. Lindberg	B. S. Rice	Buffalo Niagara Elec. Corp., 500 Elec. Bldg., Buffalo 3, N. Y.
North Carolina	4	Mar. 21, '29	187	E. W. Olschner	C. R. Jones	Carolina Telephone & Telegraph Co., Tarboro, N. C.
North Texas	7	May 18, '28	335	Wendell C. Fowler	J. M. Hagler	Southwestern Bell Telephone Co., 810 Telephone Bldg., Dallas 2, Texas
Oklahoma City	7	Feb. 16, '22	159	Frank P. Kasper	Harold L. Pickens	Allis-Chalmers Mfg. Co., 901 West Grand, Oklahoma City 4, Okla.
Panhandle	7	Sept. 8, '47		Earl R. Price	George W. Dupree	Southwestern Public Service Company, Amarillo, Texas
Philadelphia	2	Feb. 18, '03	1,180	W. R. Clark	H. H. Sheppard	Rumsey Electric Co., 1007 Arch St., Philadelphia 7, Pa.
Pittsburgh	2	Oct. 13, '02	814	A. C. Monteith	H. H. Wagner	Pennsylvania Transformer Co., 808 Ridge Ave., Pittsburgh 12, Pa.
Pittsfield	1	Mar. 25, '04	225	W. S. Fielding	F. H. Judkins	General Elec. Co., 100 Woodlawn Ave., Pittsfield, Mass.
Portland	9	May 18, '09	382	M. D. Duffy	M. M. Ewell	Westinghouse Elec. Corp., 914 U. S. Nat'l. Bank Bldg., 309 S. W. 6th Ave., Portland 4, Oregon
Providence	1	Mar. 12, '20	127	Edward R. Coop	George E. Andrews, Jr.	Engineering Dept., Narragansett Elec. Co., Providence 1, R. I.
Rochester	1	Oct. 9, '14	180	A. F. Martin	C. G. Plomasen	285 Cooper Road, Rochester 12, N. Y.
Rock River Valley	5		48	Kenneth M. Sparrow	Warner A. Johnson	1322 South Chicago, Freeport, Illinois
St. Louis	7	Jan. 14, '03	413	E. S. Rehagen	R. N. Slinger	General Elec. Co., 112 N. 4th St., St. Louis, Mo.
San Diego	8	Jan. 18, '39	124	George E. Jenner	Joseph F. Sinnott	2265 Juan St., San Diego 3, Calif.
San Francisco	8	Dec. 23, '04	951	J. L. Buckley	T. C. McFarland	Elec. Engg. Dep't., University of California, Berkeley 4 Calif.
Schenectady	1	Jan. 26, '03	764	B. H. Caldwell	J. C. Page	Central Station Engg. Div., General Elec. Co., Schenectady 5, N. Y.
Seattle	9	Jan. 19, '04	330	H. M. Gustafson	W. J. Mosley	Puget Sound Power & Light Co., Seattle 1, Washington
Sharon	2	Dec. 11, '25	150	R. L. Brown	E. W. Tipton	R. F. D. 2, Sharon Mercer Road, Sharon, Pa.
Shreveport	4	Sept. 25, '47		S. M. Sharp	Francis W. Ringer	P. O. Box 1107, Shreveport 83, La.
South Bend	5	Feb. 26, '41	85	Arthur J. Quigley	John W. Leadbetter	314 Peashway St., South Bend 17, Indiana
South Carolina	4	Mar. 2, '40	66	Charles O. Warren	Max G. Toole	P. O. Box 42, Navy Yard, Charleston 1, S. C.
South Texas	7	May 23, '30	101	S. R. Friedsam	L. L. Amrs	700 East 23½ St., Austin 22, Texas
Spokane	9	Feb. 14, '13	142	H. C. Glaze, Jr.	T. W. MacLean	Washington Water Power Co., 825 West Trent Ave., Spokane 6, Washington
Springfield	1	June 29, '22	78	Frederick G. Webber	Weyman E. Maxwell	77 Ellsworth Ave., Springfield 8, Mass.
Syracuse	1	Aug. 12, '20	187	W. C. Jenkins	L. M. Moore	Central N. Y. Power Corp., 300 Erie Blvd. West, Syracuse 2, N. Y.
Toledo	2	June 3, '07	97	Conrad H. Johnson	Walter M. Campbell	2145 Central Grove Ave., Toledo, Ohio
Toronto	10	Sept. 30, '03	513	T. G. D. Churchill	H. R. Osborne	Ferranti Elec. Ltd., Mount Dennis, Toronto, Ont., Canada
Tulsa	7	Oct. 1, '37	123	L. F. Rylander	Dick Ray	Nelson Elec. Mfg. Co., 217 North Detroit, Tulsa 1, Okla.
Urbana	5	Nov. 25, '02	74	W. E. Miller	H. N. Hayward	Dept. of Elec. Engg., University of Illinois, Urbana, Illinois
Utah	9	Mar. 9, '17	103	D. R. Hoopes	John A. McDonald	General Elec. Co., P. O. Box 779, Salt Lake City 1, Utah
Vancouver	10	Aug. 22, '11	143	Henry W. Smith	W. J. Lind	4093 West 13th Ave., Vancouver, B. C., Canada
Virginia	4	May 19, '22	180	Wm. A. Murray	Wm. T. Johns, Jr.	506 Richmond Trust Bldg., Richmond 19, Va.
Washington	2	Apr. 9, '03	769	Norman B. Ames	Ralph D. Bennett	Quarters B, Naval Ordinance Lab., Silver Spring 19, Md.
West Virginia	2	Apr. 9, '40	96	R. F. Norwood	C. M. Hunt	P. O. Box 1906, Charleston 27, W. Va.
Wichita	7	Sept. 16, '37	84	R. Richard Jenner	C. W. Halferty	Kansas Gas & Elec. Co., 201 N. Market St., Wichita 1, Kansas
Worcester	1	Feb. 18, '20	78	Donald G. MacMillan	Wilfred G. Coleman	General Elec. Co., 507 Main St., Worcester 8, Mass.
Total Sections	80		25,336			

Geographical District Executive Committees

District	Chairman (Vice-President, AIEE)	Secretary (District Secretary)	Chairman, District Committee on Student Activities
1 North Eastern	E. W. Davis, Simplex Wire & Cable Co., 79 Sidney St., Cambridge 39, Mass.	Victor Siegfried, American Steel & Wire Co., Worcester 7, Mass.	E. R. McKee, University of Vermont, Burlington, Vt.
2 Middle Eastern	G. W. Bower, 127 Hopkins Ave., Haddonfield, N. J.	A. C. Muir, Berwind-White Coal Mining Co., 1138 Commercial Trust Bldg., Philadelphia 2, Pa.	P. L. Hoover, Case Institute of Technology, Cleveland 6, Ohio
3 New York City	O. E. Buckley, Bell Telephone Laboratories, Inc., 463 West St., New York 14, N. Y.	J. L. Callahan, R.C.A. Laboratories Division, Radio Corporation of America, 66 Broad St., New York 4, N. Y.	Harry Baum, College of the City of New York, 139th St. & Convent Ave., New York, N. Y.
4 Southern	J. H. Berry, Electric Dept., Virginia Electric and Power Co., Norfolk 1, Va.	C. B. Galphin, 1028 Central Ave., Charlotte 4, N. C.	W. O. Leffell, University of Tennessee, Knoxville, Tenn.
5 Great Lakes	T. G. LeClair, Commonwealth Edison Co., 72 W. Adams St., Chicago 90, Ill.	N. C. Pearcy, Public Utility Engg. & Service Corp., 231 S. La Salle St., Chicago 4, Ill.	Robert E. Beam, The Technological Institute, Northwestern University, Evanston, Ill.
6 North Central	I. M. Ellestad, Northwestern Bell Telephone Co., 823 Telephone Bldg., Omaha 2, Nebr.	M. L. Burgess, Westinghouse Electric Corp., 117 N. 13th St., Omaha 2, Nebr.	John E. Martin, University of Denver, Denver, Colo.
7 South West	R. F. Danner, Oklahoma Gas & Electric Co., Oklahoma City 1, Okla.	W. B. Stephenson, Southwestern Bell Telephone Co., Oklahoma City 2, Okla.	Arthur S. Brown, University of Arkansas, Fayetteville, Ark.
8 Pacific	D. I. Cone, Pacific Tel. & Tel. Co., 140 New Montgomery St., San Francisco 5, Calif.	B. D. Dexter, 245 Market St., San Francisco, Calif.	W. G. Hoover, Stanford University, Stanford University, Calif.
9 North West	C. F. Terrell, Puget Sound Power & Light Co., 860 Stuart Bldg., Seattle, Wash.	C. H. Cutter, 814 Securities Bldg., Seattle 1, Wash.	H. P. Lickey, Washington State College, Pullman, Wash.
10 Canada	D. G. Geiger, Bell Telephone Co. of Canada Ltd., 76 Adelaide St. W., Toronto 1, Ont.	J. Taylor Fisher, 76 Adelaide St. West, Toronto 1, Ont.	W. B. Coulthard, University of British Columbia, Vancouver, B. C.

NOTE: Each District executive committee includes also the chairmen and secretaries of all Sections within the District and the District vice-chairman of the AIEE membership committee.

Subsections

Name	Chairman	Secretary	Secretary's Address
Albuquerque (New Mexico–West Texas Section)	Walter F. Hardgrave		
Baton Rouge (New Orleans Section)	A. K. Ramsey, Jr.	F. R. Adams	Southern Bell Tel. & Tel. Co., 555 Florida Street, Baton Rouge 8, La.
Binghamton Area (Ithaca Section)	M. F. Skinker	K. S. Koon	I. B. M. Corp., Endicott, N. Y.
Boulder City (Los Angeles Section)	C. P. Christensen	Wade H. Taylor	Bureau of Reclamation, Boulder City, Nevada
Canton (Akron Section)	R. C. Wey	H. E. Rue	116 26th St., N. E., Canton, Ohio
Casper, Wyo. (Denver Section)	B. A. Fleshman	C. R. McLean	Mountain States Power Co., Casper, Wyo.
Charleston (South Carolina Section)	David T. Coleman	C. Y. House, Jr.	P. O. Box 303, Charleston, S. C.
Charlotte (North Carolina Section)	Russell Ranson	J. S. Myers	P. O. Box 1969, Charlotte, N. C.
Corpus Christi (South Texas Section)	George A. Mills		
Fort Worth (North Texas Section)	Leland B. Bass	J. L. Candry	Texas Elec. Service Co., Electric Bldg., Fort Worth 2, Texas
Fox River Valley (Milwaukee Section)	Arthur E. Carlson	Jesse W. Pomaral	708 East Hancock Street, Appleton, Wis.
Freeport (Houston Section)	D. S. Sandlin	W. F. Albright	Box 725, Lake Jackson, Tex.
Fresno Division (San Francisco Section)	E. S. Dreischmeyer	F. E. Miller	Pacific Gas and Electric Co., Fresno, Calif.
Great Falls (Montana Section)	Dennis A. Johnson	Sidney E. McArthur	Montana Power Co., Morony Dam, Great Falls, Montana
Hamilton (Toronto Section)	W. J. Porter	C. E. Moorhouse	Canadian Westinghouse Co., Ltd., Hamilton, Ontario, Canada
Hampton Roads (Virginia Section)	A. I. Osborne	Hayward W. Evans	Virginia Elec. & Power Co., Norfolk, Va.
Hudson Valley Division (New York Section)	H. A. McLaughlin	T. F. X. Vail	Central Hudson Gas & Elec. Corp., South Road, Poughkeepsie, N. Y.
Jacksonville (Florida Section)	R. L. McCall		
Lake Charles (New Orleans Section)	G. V. Cooper	J. W. Kirkland	Gulf States Utilities Co., 314 Broad St., Lake Charles, Florida
Lancaster–York (Maryland Section)	J. L. Stauffer	W. H. Freund	R. C. A. Mfg. Co., Lancaster, Pa.
Mayaguez Division (New York Section)	Miguel Wiewall, Jr.	Modesto I. Beauchamp	College of A. & M. Arts, Univ. of Puerto Rico, Mayaguez, Puerto Rico
Miami (Florida Section)	P. J. Carlin		
New Jersey Division (New York Section)	Leland F. Stone	L. J. Lunas	Westinghouse Electric Corp., 95 Orange Street, Newark 1, N. J.
Niagara (Toronto Section)	C. W. Baker	W. G. Barr	1888 Main Street, Niagara Falls, Ontario, Canada
Niagara Falls (Niagara–Frontier Section)	J. M. Davidson	J. A. Persson	368 Spruce Avenue, Niagara Falls, N. Y.
Ottawa (Montreal Section)	G. R. Davis	R. M. Morris	National Research Council, Sussex St., Room 70, Ottawa, Ontario, Canada
Quad–Cities (Iowa Section)	R. B. Miller	E. C. Lister	Stanley Engineering Co., Muscatine, Iowa
Richmond (Virginia Section)	P. R. Spracher	Bruce C. Halsted	Allis-Chalmers Mfg. Co., Richmond Trust Bldg., Richmond 19, Va.
Roanoke (Virginia Section)		J. H. Pharis	425 Allison Ave. S. W., Roanoke 16, Va.
Sacramento Division (San Francisco Section)	James R. Miller	Earle S. Prud'homme	General Electric Co., Forum Bldg., Sacramento, Calif.
Saginaw Valley (Michigan Section)	Gordon S. Marvin	George Grant, III.	2115 Gratiot Ave., Saginaw, Michigan
San Jose Division (San Francisco Section)	C. Harold Johnson	J. Scott Kay	Pacific Gas and Electric Co., 86 S. 3rd St., San Jose Calif.
San Juan Division (New York Section)	Ivan Megwinoff	Victor M. Cataldo	Flores Street 155, Santurce, Puerto Rico
Shasta Division (San Francisco Section)	T. N. Kreiberg	W. T. Hannum	Pacific Gas and Electric Co., 301 Main Street, Chico, Calif.
Tampa (Florida Section)	R. S. Davis		
West Central Texas Division (North Texas Section)	Don W. Whitaker	E. N. Mitchell	General Meter Dept., West Texas Utilities, Abilene, Texas
Wilmington (Philadelphia Section)	N. O. Rowe	Elmer W. Randall	E. I. du Pont de Nemours & Co., Wilmington, Del.
Zanesville (Columbus Section)	W. B. Abele	Robert P. Thompson	329 Putnam Avenue, Zanesville, Ohio

Student Branches

Name and Location	District	Counselor (Member of Faculty)
Akron, University of, Akron, Ohio	2	A. J. Fairburn
Alabama Polytechnic Institute, Auburn	4	
Alabama, University of, University	4	William J. Miller
Alberta, University of, Edmonton, Canada	10	R. E. Phillips
Arizona, University of, Tucson	8	J. G. Clark
Arkansas, University of, Fayetteville	7	A. S. Brown
British Columbia, University of, Vancouver, Canada	10	W. B. Coulthard
Brooklyn, Polytechnic Inst. of, Brooklyn, N. Y. (Day)	3	F. Wahlers
(Evening)	3	Anthony B. Giordano
Brown University, Providence, R. I.	1	F. N. Tompkins
Bucknell University, Lewisburg, Pa.	2	George Irland
California Institute of Technology, Pasadena	8	William H. Pickering
California, University of, Berkeley	8	R. M. Saunders
Carnegie Institute of Technology, Pittsburgh, Pa.	2	E. M. Williams
Case Institute of Technology, Cleveland, Ohio	2	P. L. Hoover
Catholic University of America, Washington, D. C.	2	T. J. MacKavanagh
Cincinnati, University of, Cincinnati, Ohio	2	A. C. Herweh
Clarkson College of Technology, Potsdam, N. Y.	1	Alfred R. Powers
Clemson Agricultural College, Clemson, S. C.	4	F. T. Tingley
Colorado A and M College, Ft. Collins	6	C. F. Chinburg
Colorado, University of, Boulder, Colo.	6	Platt Wicks
Columbia University, New York, N. Y.	3	W. A. LaPierre
Connecticut, University of, Storrs	1	L. E. Williams
Cooper Union, New York, N. Y.	3	Norman L. Towle
Cornell University, Ithaca, N. Y.	1	B. K. Northrop
Delaware, University of, Newark	2	R. E. Kuehn
Denver, University of, Denver, Colo.	6	John E. Martin
Detroit, University of, Detroit, Mich.	5	H. O. Warner
Drexel Institute of Technology, Philadelphia, Pa.	2	F. C. Powell
Duke University, Durham, N. C.	4	Otto Meier, Jr.
Florida, University of, Gainesville	4	F. H. Pumphrey
George Washington University, Washington, D. C.	2	Milton K. Akers
Georgia School of Technology, Atlanta, Ga.	4	H. B. Duling
Harvard University, Cambridge, Mass.	1	John C. Fisher
Idaho, University of, Moscow	9	J. H. Johnson
Illinois Institute of Technology, Chicago	5	E. T. B. Gross
Illinois, University of, Urbana	5	E. A. Reid
Navy Pier Div., Chicago		
Iowa State College, Ames	5	B. S. Willis
Iowa, University of, Iowa City	5	E. B. Kurtz
ohns Hopkins University, Baltimore, Md.	2	F. Hamburger, Jr.
Kansas State College, Manhattan	7	Joe E. Ward
Kansas, University of, Lawrence	7	David D. Robb
Kentucky, University of, Lexington, Ky.	4	Brinkley Barnett
Lafayette College, Easton, Pa.	2	Finley W. Smith
Lehigh University, Bethlehem, Pa.	2	J. L. Beaver
Louisiana State University, Baton Rouge	4	W. D. Morris
Louisville, University of, Louisville, Ky.	4	S. T. Fife
Maine, University of, Orono	1	W. J. Creamer
Manhattan College, New York, N. Y.	3	Robert T. Weil
Marquette University, Milwaukee, Wis.	5	E. W. Kane
Maryland, University of, College Park	2	L. J. Hodgins
Massachusetts Institute of Technology, Cambridge	1	E. W. Boehne
Michigan College of Mining and Tech., Houghton	5	G. W. Swenson
Michigan State College, East Lansing	5	J. A. Strelnoff
Michigan, University of, Ann Arbor	5	J. S. Gault
Milwaukee School of Engineering, Milwaukee, Wis.	5	R. J. Ungrodt
Minnesota, University of, Minneapolis	5	J. H. Kuhlmann
Mississippi State College, State College	4	Harry C. Simrall
Missouri School of Mines and Metallurgy, Rolla	7	I. H. Lovett
Missouri, University of, Columbia	7	Clifford M. Wallis
Montana State College, Bozeman	9	Robert C. Seibel
Nebraska, University of, Lincoln	6	C. W. Rook
Nevada, University of, Reno	8	I. J. Sandorf
Newark College of Engineering, Newark, N. J.	3	Wm. Jordan, 3rd.
Total Branches	127	

Name and Location	District	Counselor (Member of Faculty)
New Hampshire, University of, Durham, N. H.	1	Wm. B. Nuken
New Mexico College of Agriculture and Mechanic Arts, State College	7	Russell L. Riese
New Mexico, University of, Albuquerque	7	E. C. Bickley
New York, College of the City of, New York, N. Y.	3	Harry Baum
New York University, New York	3	S. G. Lutz
North Carolina State College, Raleigh	4	W. D. Stevenson, Jr.
North Dakota State Agricultural College, Fargo	5	Harry S. Dixon
North Dakota, University of, Grand Forks	5	J. C. Hogan
Northeastern University, Boston, Mass.	1	R. G. Porter
Northwestern University, Evanston, Ill.	5	R. Beam
Norwich University, Northfield, Vt.	1	F. A. Spencer
Notre Dame, University of, Notre Dame, Ind.	5	L. F. Stauder
Ohio Northern University, Ada	2	Ralph E. Walter
Ohio State University, Columbus	2	E. E. Kimberly
Ohio University, Athens	2	
Oklahoma Agricultural and Mechanical College, Stillwater	7	Albrecht Naeter
Oklahoma, University of, Norman	7	Gerald Tuma
Oregon State College, Corvallis	9	M. J. Kofoid
Pennsylvania State College, State College	2	A. P. Powell
Pennsylvania, University of, Philadelphia	2	Kenneth Fegley
Pittsburgh, University of, Pittsburgh, Pa.	2	R. C. Gorham
Pratt Institute Brooklyn, N. Y.	3	Donald H. Wright
Princeton University, Princeton, N. J.	2	J. E. Paul
Puerto Rico, University of, Mayagues, P. R.	3	Miguel Wiewall, Jr.
Purdue University, Lafayette, Ind.	5	C. R. Nichols
Rensselaer Polytechnic Institute Troy, N. Y.	1	E. D. Broadwell
Rhode Island State College, Kingston	1	W. C. Birtwell
Rice Institute, Houston, Tex.	7	J. S. Waters
Rose Polytechnic Institute, Terre Haute, Ind.	5	C. C. Knipmeyer
Rutgers University, New Brunswick, N. J.	3	P. S. Creager
Santa Clara, University of, Santa Clara, Calif.	8	W. J. Warren
South Carolina, University of, Columbia	4	Samuel Litman
South Dakota State College, Brookings	5	Wm. H. Gamble
South Dakota School of Mines and Technology, Rapid City	6	J. O. Kammerman
Southern California, University of, Los Angeles	8	Rodney C. Lewis
Southern Methodist University, Dallas, Tex.	7	J. W. Tatum
Stanford University, Stanford University, Calif.	8	W. G. Hoover
Stevens Institute of Technology, Hoboken, N. J.	3	Wm. L. Sullivan
Swarthmore College, Swarthmore, Pa.	2	Howard M. Jenkins
Syracuse University, Syracuse, N. Y.	1	Leroy A. Mullin
Tennessee, University of, Knoxville	4	W. O. Leffell
Texas, Agricultural and Mechanical College of, College Station	7	N. F. Rode
Texas Technological College, Lubbock	7	C. V. Bullen
Texas, University of, Austin	7	A. J. McCrocklin, Jr.
Toronto, University of, Toronto, Ontario, Canada	10	L. S. Lauchland
Tufts College, Medford, Mass.	1	A. H. Howell
Tulane University, New Orleans, La.	4	Allan S. Pincus
Union College, Schenectady, N. Y.	1	Owen G. Owens
Utah, University of, Salt Lake City	9	O. C. Haycock
Vanderbilt University, Nashville, Tenn.	4	S. R. Schealer
Vermont, University of, Burlington	1	E. R. McKee
Villanova College, Villanova, Pa.	2	
Virginia Military Institute, Lexington	4	J. S. Jamison
Virginia Polytechnic Institute, Blacksburg	4	Claudius Lee
Virginia, University of, Charlottesville	4	L. R. Quarles
Washington, State College of, Pullman	9	H. F. Lickey
Washington, University of, Seattle	9	V. L. Palmer
Washington University, St. Louis, Mo.	7	Pierre M. Honnell
Wayne University, Detroit, Mich.	5	
West Virginia University, Morgantown	2	A. H. Forman
Wisconsin, University of, Madison	5	John C. Weber
Worcester Polytechnic Institute, Worcester, Mass.	1	D. C. Alexander
Wyoming, University of, Laramie	6	R. O. Trueblood
Yale University, New Haven, Conn.	1	A. G. Conrad